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Our Fragile Atmosphere: The Greenhouse Effect and Ozone Depletion

Our Fragile Atmosphere: The Greenhouse Effect and Ozone Depletion

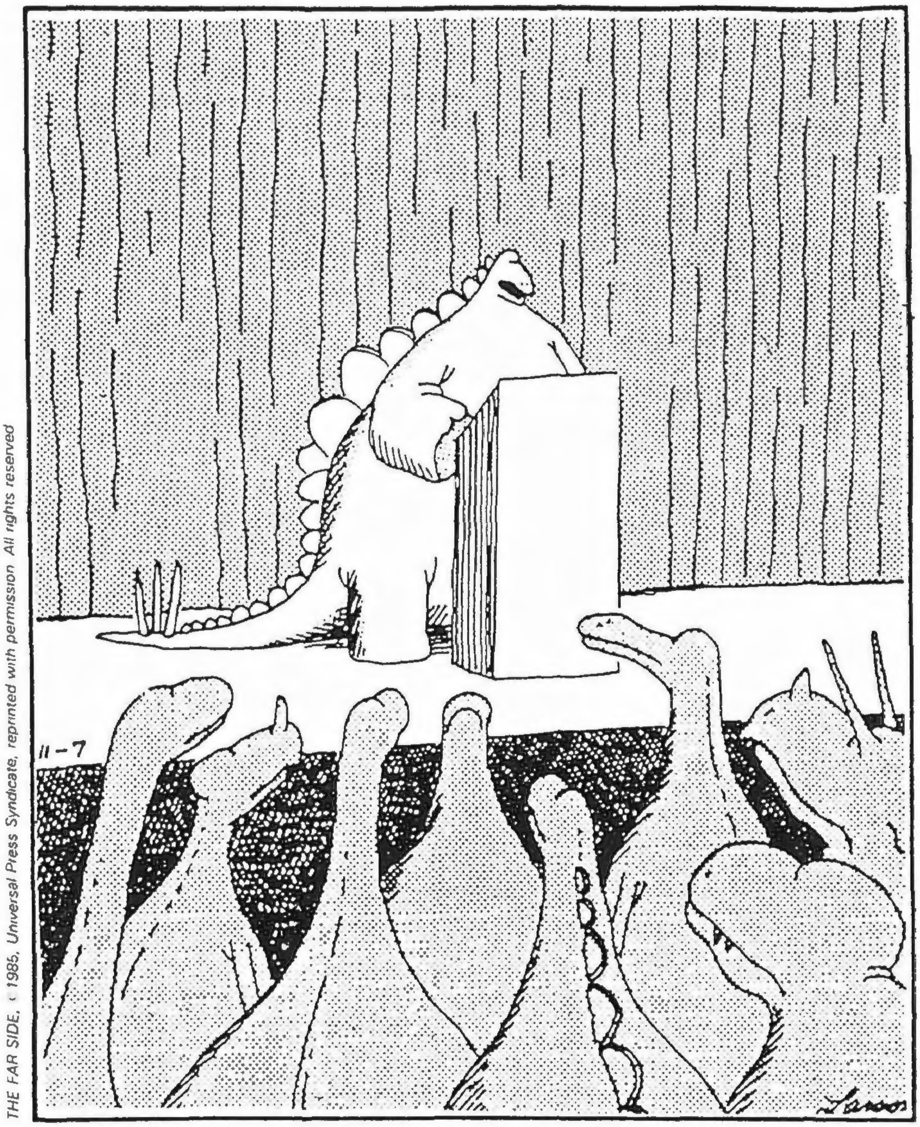
Seldom have environmental issues brought such a chilling awareness of the vulnerability of the human race as the "greenhouse effect" and depletion of the planet's layer of protective ozone in the stratosphere. This *EPA Journal* explores these problems and their implications for the future.

EPA Administrator Lee M. Thomas sets a perspective and presents the Agency's ideas on how to approach these two problems.

One of the originators of the ozone depletion theory explains that theory in layman's terms. A physician discusses the threat of skin cancer posed by a depleted ozone layer. A representative of an industrial organization looks at possible action that might be taken to limit certain chemicals that are useful to industry and consumers, but which may contribute to ozone depletion.

The theory behind the greenhouse effect—the other suspected atmospheric danger to earth's environment—is explained by a leading researcher. The awakening of the public to the greenhouse issue is chronicled. A major consequence of the greenhouse effect—a rise in sea levels—is explained by an EPA specialist on the problem.

Dr. Mostafa K. Tolba, head of the U.N. Environment Programme, discusses the global challenges that the greenhouse effect and depletion of the ozone layer are presenting. U.S. Senator John H. Chafee, R-R.I., who recently chaired Senate subcommittee hearings on these planetary problems, offers a key Congressional view.



"The picture's pretty bleak, gentlemen . . . The world's climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut."

Closing the presentation is an article on the sophisticated, precedent-setting science that is making it possible to understand the phenomena of the greenhouse effect and ozone layer reduction.

In an unrelated article, a U.S. environmental leader discusses some new turns being taken by environmentalism in this country. A historical feature reports on two little-noticed, but major smog episodes in New York City in 1953 and 1966. And a final article presents some recent findings about the effects on the economy of spending for environmental cleanup.

This issue of *EPA Journal* concludes with two regular features. □

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EPA is charged by Congress to protect the nation's land, air, and water systems. Under a mandate of national environmental laws, the agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life.

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Front Cover: Sun at horizon, Casco, ME. The greenhouse effect and depletion of the stratospheric ozone layer illustrate the fragility of our atmosphere and the vulnerability of life on the planet. Photo by Dean Abramson, Folio, Inc.

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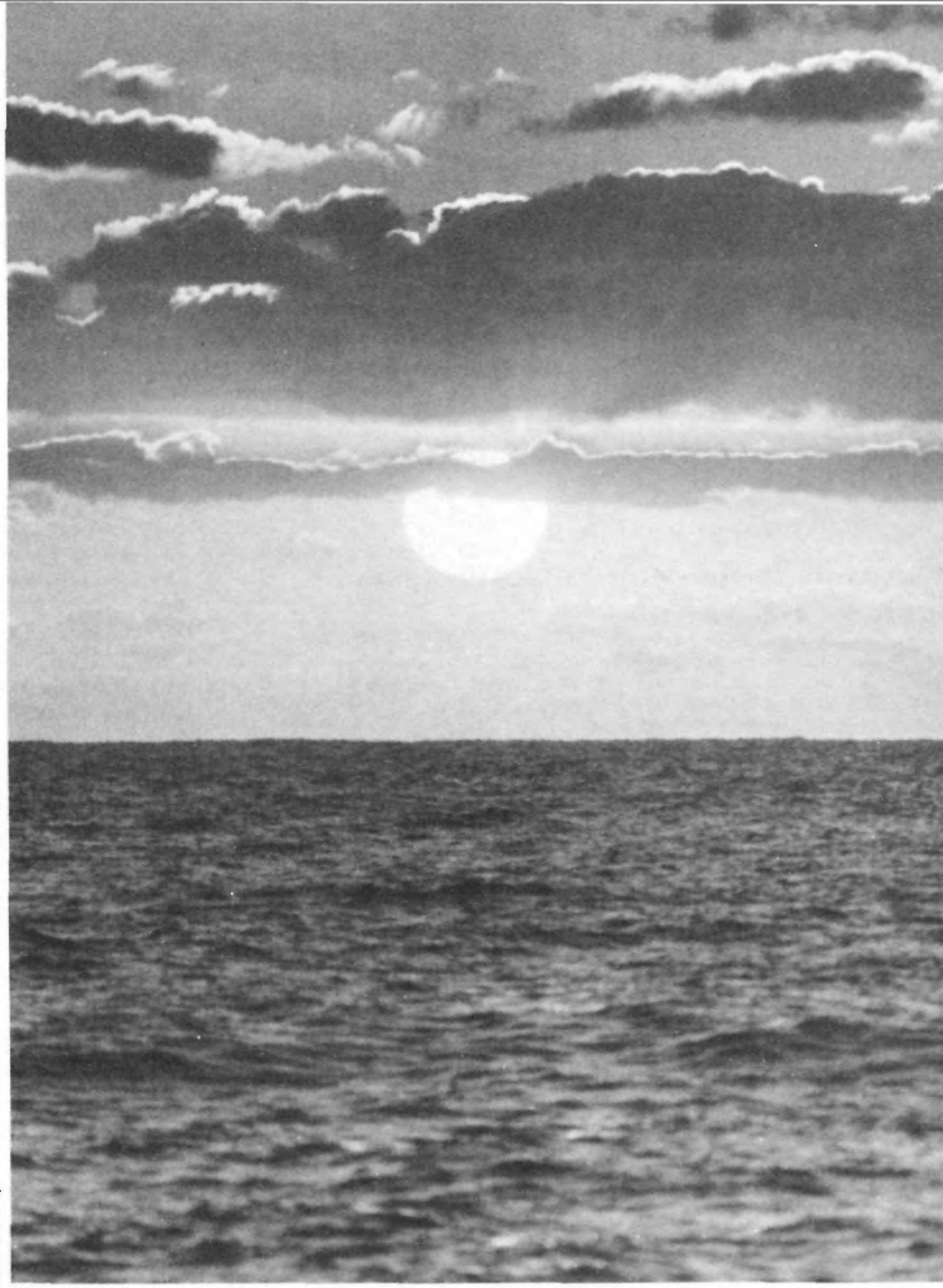
Global Challenges at EPA

by Lee M. Thomas



Steve Delaney

Americans enjoy one of the world's highest standards of living. Our technological achievements during the past half century are unequalled. They have contributed significantly to improvements in our overall quality of life.

Today, we live longer and better than ever before. We have more conveniences. More labor-saving devices. More products and services designed to make our lives comfortable.

Unfortunately, the advances that contributed to the standard of living we enjoy today carried with them hidden costs. This is particularly true when we consider the environmental costs. As we improved our material well-being, the quality of our environment suffered from smokestacks, discharge pipes, and dumps that contaminated our air, water, and land.

Since 1970, we have made tremendous progress in addressing and remedying our past environmental mistakes. The air in our cities is far cleaner today than it was 20 years ago. The quality of thousands of miles of rivers and streams has improved. And our hazardous waste and toxics programs are protecting our land and ground-water resources.

But the job of managing and improving the quality of our environment is far from finished. Despite our successes with traditional pollutants, new challenges are at hand.

These new challenges are significantly different from those we have already met. They are more subtle and more complex. No longer are we fighting gross emissions from obvious sources. Rather, we are confronting trace toxics in our air, water, and food.

We are dealing with the cross-media effects of pollution control — the movement of contaminants from one environmental medium to another. For example, pollutants removed from the water and incinerated may threaten the air. If we place them on the land, they may ultimately contaminate our ground water.

We are learning, too, that some of the challenges we face today are global in nature. Both the sources of problems and the solutions to them are international in scope. Depletion of the stratospheric ozone layer is one example. The phenomenon of global warming — the so-called greenhouse effect — is another.

We do not fully understand either. Uncertainties exist concerning the causes of ozone depletion and greenhouse warming. The complex processes that lead to both are not fully defined.

There is consensus, however, that both are due to increased industrial and agricultural activity over the past 200 years, and particularly since the end of World War II. The burning of coal, oil, and natural gas today adds about five gigatons of carbon dioxide to the atmosphere each year. Combustion of these same fossil fuels and increased uses of fertilizers add substantial quantities of nitrous oxides as well.

Chlorofluorocarbons (CFCs), discovered in the 1930s, are widely used as refrigerants, aerosol propellants, foam-blowing agents, and solvents. The atmospheric levels of CFCs are growing at a rate of five to seven percent annually.

And methane from a variety of sources, many of them agricultural, has also been added to the atmosphere in substantial quantities during recent decades.

Many scientists believe that these chemicals are causing important changes in the chemical composition of our atmosphere. Some are ozone

(Thomas is Administrator of EPA.)

Sunset over the Atlantic Ocean. The future warming of the planet—the greenhouse effect—has serious implications for rising sea levels and changing weather patterns.

depleters. Others partially offset depletion. But there is growing concern that increased use of CFCs could lead to net ozone depletion.

Stratospheric ozone acts as a shield against harmful solar radiation. A significant reduction of ozone in the upper atmosphere could mean long-term increases in the incidence of skin cancer and cataracts worldwide. It could also have significant impacts on our terrestrial and aquatic ecosystems.

At the same time, the gases affecting ozone also exhibit greenhouse properties. That is, they trap solar energy in the atmosphere. Thus, they could contribute to future warming of the earth.

The effects of global warming over the long term go well beyond higher temperatures. The greenhouse effect could also result in substantially altered rainfall patterns, increases in sea level, loss of soil moisture, and changes in the movement of storms. These shifts could affect agriculture, forests, wetlands, water resources, and coastal areas.

While concerns about these problems are urgent, we do not believe that harm can yet be attributed directly to them. On the other hand, the nature of both ozone depletion and global warming are such that if we wait until health and environmental impacts are manifest it might be too late to take adequate steps to address these problems.

As we look at solutions, we must recognize the unusual nature of these new challenges. For both ozone depletion and the greenhouse effect we are faced with problems where the sources of pollution, as well as the potential impacts, are distributed unevenly throughout the world — not just between two countries or within one region. Furthermore, in neither case will the impacts for a particular country necessarily be proportional to its level of emissions of the gases in question.

Thus, traditional approaches to problem solving — domestic legislation, rulemaking, and enforcement — are inadequate to deal with this new class of problems. The United States has taken some important regulatory steps to control CFCs (we banned their use in aerosols in 1978), and we are committed to a decision on the need for additional rules by November 1987. But more will have to be done beyond these unilateral actions.

Recognizing this, EPA's stratospheric ozone protection program incorporates concurrent domestic and international efforts leading to a coupled decision during the next year on an international protocol and possible domestic regulations. We initiated the program over a year ago.

Since then, we have held a number of domestic public workshops, participated in two international workshops sponsored by the United Nations Environment Programme (UNEP), and co-sponsored a major scientific conference on the effects of ozone depletion and climate. In addition, we have conducted a major scientific risk assessment, which has just been reviewed by the EPA Science Advisory Board.

More recently, the U.S. played a leading role in the first round of international negotiations on an ozone layer protocol, held in Geneva during the first week of December. With EPA assistance, the U.S. delegation was a strong advocate of the view that meaningful near- and long-term measures are needed to protect the ozone layer. Although there is still a long way to go, I am hopeful that we will see an international protocol adopted in 1987.

Our experiences with the ozone problem have helped us to identify a number of elements that I am convinced will come into play as we strive to address this new generation of international environmental challenges.

First, we must understand the magnitude of global environmental challenges. Our goal, of course, must be to safeguard human health and the environment.

Second, we must realize that there will always be scientific uncertainty associated with these complex problems. We will have to be prepared to act despite these uncertainties.

Third, if we are to succeed in addressing global issues, we must deal with them in a global context. UNEP has shown strong interest in the area of ozone depletion. We will work with them to provide the leadership needed to move forward.

Fourth, we must conduct our work in a way that reflects the urgency of the problems we face but that does not create undue alarm. We do not believe we face imminent dangers. Our approach to solving these problems should be one of orderly and cooperative action that gets the job done in a way that will protect human health and the environment and minimize cost and disruption.

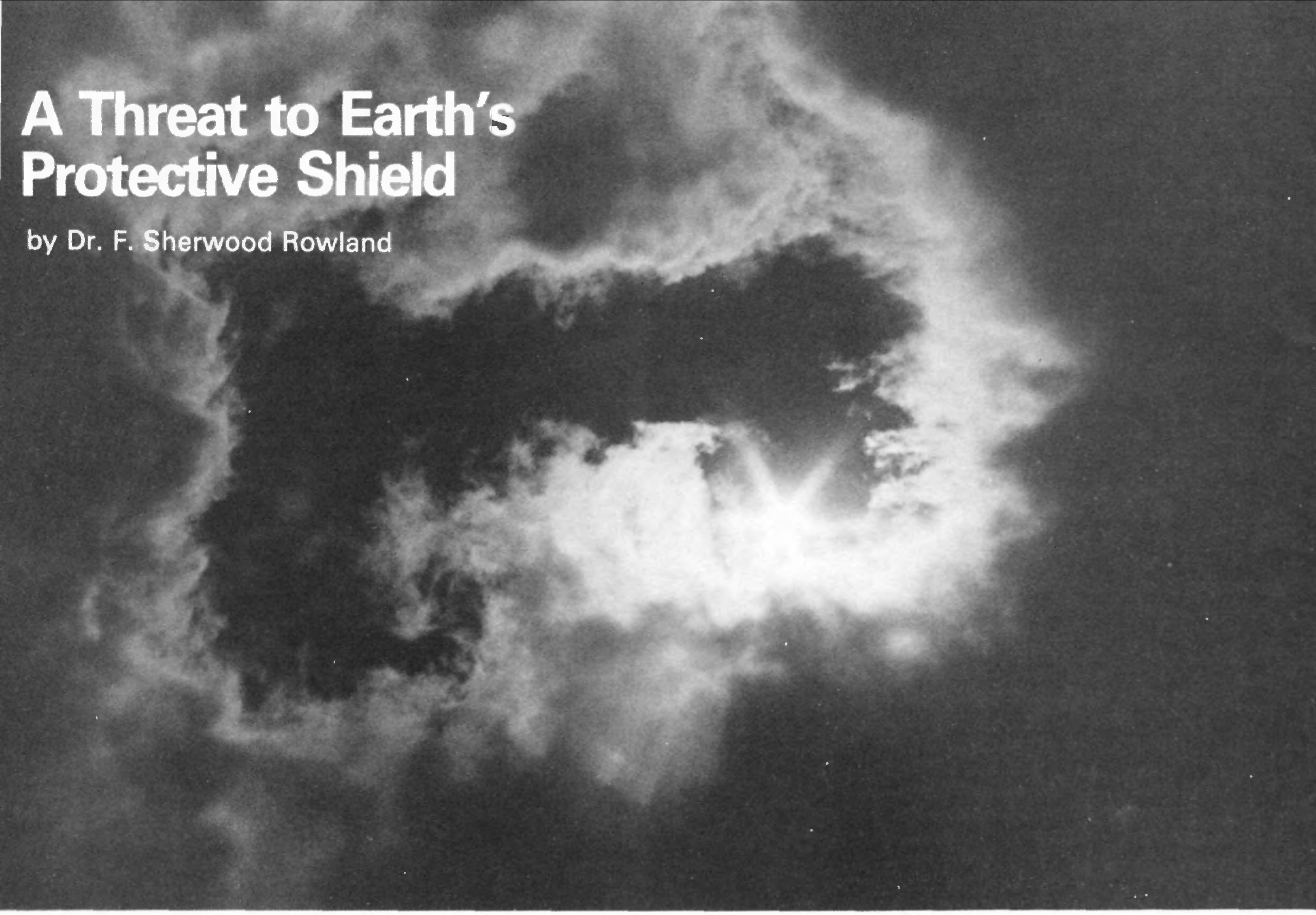
Fifth, wherever possible our actions should be technology-forcing. We need strong incentives for the development and use of substitute chemicals that are both acceptable to industry and consumers, yet benign to human health and the environment.

Finally, we must devise solutions that are equitable to all nations, including our own. The United States has led the way in regulating CFCs, but we cannot solve international environmental problems alone. All nations and their industries should help shoulder the economic burdens of protecting the global environment.

Dealing with global environmental problems like ozone depletion and greenhouse warming will be one of this Agency's most difficult challenges in the years ahead. I believe we are well on our way to establishing the international framework of scientific research and cooperative actions that will be critical to our success. □

A Threat to Earth's Protective Shield

by Dr. F. Sherwood Rowland



Steve Delaney

The recent discovery that an "ozone hole" has developed over Antarctica has once again focused public attention and concern on this critical component of the earth's atmosphere. Based on extensive measurements from both ground- and satellite-based instruments, we can state with certainty that very large decreases in ozone have occurred above Antarctica over the past decade during the months of September through mid-November. Ozone is the key atmospheric gas which shields us—and all other biological species—against damaging solar ultraviolet radiation. While the causes of the massive seasonal loss of ozone over Antarctica are not yet fully understood, and its implications for the ozone layer above the rest of the earth are also uncertain (see box on page 6), there can be no doubt that the gases released from certain human activities are threatening the integrity of this protective ozone layer.

(Dr. Rowland is Professor of Chemistry, Daniel G. Aldrich, Jr., Endowed Chair, University of California, Irvine, and is one of the originators of the ozone depletion theory.)

The Role of Ozone

Unlike the abundant atmospheric gases oxygen and nitrogen, ozone (O_3) represents only a tiny fraction of the total atmosphere, with an average global concentration of about 300 parts per billion in volume (300ppbv). If all of the ozone were compressed into a band of pure gas, the layer around the earth would be only three millimeters thick.

Despite its limited quantity, ozone plays a critical role in absorbing incoming solar radiation. The sun gives off radiation across a broad spectrum. The light detectable by the human eye covers the range from approximately 400 to 700 nanometers in wavelength, or from violet to red in color. Much of the "near" ultraviolet radiation (320-400 nanometers) also reaches the ground and can be tolerated by biological species at the surface. In contrast, the adjacent segment of the ultraviolet spectrum (UV-B, 290-320 nanometers) has been shown to be biologically damaging. Fortunately, most of this radiation is absorbed by ozone high in the earth's atmosphere. However, some does penetrate to the earth's surface, with larger quantities of UV-B near the Equator than at the poles. This natural variation in exposure to UV-B provides a real-life experimental setting which has supplied ample evidence of the potential damage from UV-B radiation to human health (e.g. skin cancer) and to the environment.

Complex natural forces are continually at work creating and destroying ozone in the atmosphere. This dynamic equilibrium involves first the breakdown of individual molecules of oxygen (O_2) into atomic oxygen (O) through its absorption of ultraviolet radiation. In turn, each atomic oxygen normally combines with an additional molecule of O_2 to form ozone O_3. Destruction of ozone can be caused by the occasional recombination of ozone with atomic oxygen to form two molecules of diatomic oxygen. As long as the earth's sunlit atmosphere contains molecular oxygen, as it has for more than one billion years, ozone will be maintained in this dynamic balance between formation and destruction. This balance can be altered, however, by the introduction into the atmosphere of additional ozone destroying chemicals, which shift the equilibrium toward smaller average concentrations of ozone. 1974 saw the first suggestion that a group of chemicals known as chlorofluorocarbons, or CFCs, could be a major avenue for adding chlorine to the atmosphere and disturbing the ozone balance.

CFC's were first developed by General Motors in the 1930s, after a deliberate search for an ammonia substitute in refrigeration uses. The results of this search produced a family of chemicals with properties ideal for many applications beyond refrigeration. Chemically inert, nontoxic, and easily liquified, CFCs are now used in air conditioning, packaging, and insulation, as a solvent for cleaning electronic circuit boards, and as aerosol propellants.

It is this very absence of chemical reactivity that makes CFCs so dangerous to the ozone layer. Unlike less inert compounds, CFCs are not destroyed or removed in the lower atmosphere by rainout, oxidation, or sunlight. Instead, they drift into the upper atmosphere where their chlorine components are released into the atmosphere under the effects of ultraviolet radiation, and where they encounter and destroy ozone. Almost all of these freed chlorine atoms find and react with the ozone in one to two seconds, creating chlorine oxide as a by-product. In a subsequent reaction, the chlorine oxide releases its oxygen atom to form molecular oxygen, and the chlorine atom is freed once again to repeat the process of destroying ozone. Through this continuing cycle of reactions, each chlorine atom acts as a catalyst destroying about 100,000 molecules of ozone before the chain reaction is permanently ended. The atmospheric lifetimes for the most commonly used CFC compounds (CFC-11, CFC-12, and CFC-13), in fact, have been estimated to be from 75 to 110 years.

The chemistry of the atmosphere is far more complicated than just these simple reactions involving chlorine. Current atmospheric models require more than 160 chemical reactions to simulate observed chemical features in the atmosphere. Despite this complexity, however, a clear link exists between the introduction of chlorine from CFCs and the destruction of ozone in the upper atmosphere.

Because the widespread use of CFCs by industry and consumers is essentially a post-1970 phenomenon, with yearly releases since 1974 approaching one million tons worldwide, the observed atmospheric concentrations of all three major CFCs have risen sharply. The "natural" level of chlorine in the atmosphere before 1900 is believed to have been about 0.6 ppbv, almost entirely from methyl chloride. The present chlorine level is about 3.5 ppbv, and is increasing by more than 1.0 ppbv per decade. The excellent correlation between the increase in atmospheric chlorine and the ozone losses during the Antarctic spring (see box) provides strong circumstantial evidence that CFCs are involved in this process.

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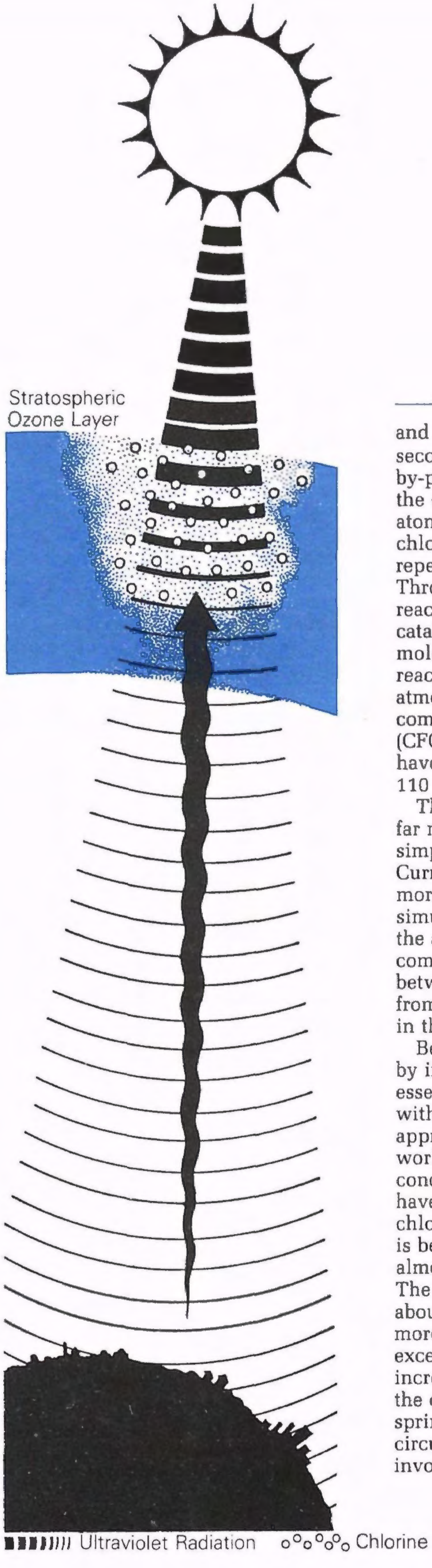


A protective layer of ozone in the upper atmosphere normally prevents harmful ultraviolet radiation from reaching the earth's surface. However, CFCs emitted from the production and use of solvents, refrigerators, air conditioners, and foam-blowing agents drift into the upper atmosphere and eventually decompose under the influence of ultraviolet radiation. The chlorine released in this process reacts with and destroys ozone in a continuing cycle of reactions that may last up to a hundred years or more. The result could be a thinning of the ozone layer and an eventual increase in ultraviolet radiation at the earth's surface.

Safeguarding Our Atmosphere

CFCs have a long record as very useful chemicals, contributing across a broad range of products to our current standard of living. At the same time, they present a grave environmental risk which can seriously affect the basic conditions of life for both current and future generations. The risks from ozone depletion have been described in reports from the National Academy of Sciences since 1976 and include not only the increased UV-B effect on humans in the form of skin cancer, but also UV-B attack on many other biological systems.

Over a decade of research has substantially improved our understanding of all aspects of the ozone layer. All of the evidence produced to date continues to implicate the CFCs as possessing severe potential for ozone depletion. Despite this growing scientific record against CFCs, world use continues to increase as more and more nations seek to improve their living standards using CFC-based products.

Industry's search for less harmful chemicals a half century ago led to the discovery of the current family of CFCs, and that same kind of ingenuity must now be harnessed to find new solutions. For example, hydrogen-containing CFC-22 has long been in major use in home air conditioners and represents a much lesser threat to stratospheric ozone because the molecule is strongly susceptible toward oxidation in the lower atmosphere. Further, past research by several companies has already led to a number of patents on Fluorocarbon-134a, which has many of the same industrial properties found in CFC-12. This compound has a negligible potential for ozone depletion because it does not contain chlorine, but is not yet in large-scale manufacture. Alternatively, industries can begin to design closed industrial processes with recycling which could dramatically reduce emissions by using these potentially harmful chemicals more efficiently.

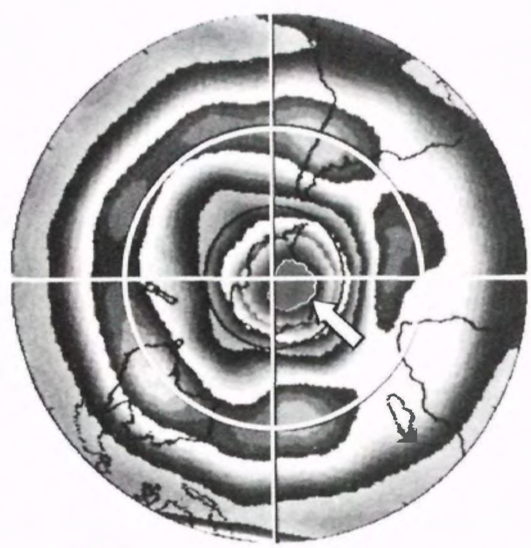
Research into reducing the global use of CFCs cannot wait for the final definitive answers from the scientific community. Because of the very long atmospheric lifetimes of CFCs, any damage done to the atmosphere will persist throughout the entire 21st century and on into the 22nd. The costs of moving expeditiously away from these suspect chemicals is a very small price compared to the large potential damages if we fail to act now. □

The Ozone Hole Over Antarctica

In May 1985, scientists from the British Antarctic Survey published data which have sent shock waves throughout the scientific community. These data showed that a 40 percent loss in total ozone has occurred since the 1960s over Halley Bay, Antarctica, during September to mid-November. These findings were totally unpredicted and unexpected. No such losses had previously been reported, either from ground-based instruments in operation since 1957 or from the extensive satellite measurements initiated in the 1970s. However, both U.S. and Japanese scientists quickly began sorting through their data sets and have confirmed that this phenomenon in Antarctica is indeed real.

With the existence of the ozone hole now thoroughly established, the research community has quickly come forth with a variety of possible explanations. Was the phenomenon part of a natural cycle linked to solar activity? Was it caused by meteorological conditions specific to the region? Why did the existing atmospheric models fail to simulate such losses? Are chlorine chemistry and chlorofluorocarbons (CFCs) the lone culprit, or do they act in combination with other chemicals or conditions?

As part of the search for scientific clues, an urgent research effort was quickly put together, and four different U.S. scientific teams were sent to Antarctica in 1986 to gather more extensive measurements of ozone and other chemical compounds as the ozone hole reappeared during September. This expedition was very successful, and the scientists held a live press conference from the McMurdo station in Antarctica in late October. They reported that evidence produced to date was inconsistent with proposed theories linking the ozone hole to solar activity or solely to meteorological forces. While stating that a chemical cause of the ozone hole was likely, they stopped short of pointing the finger at CFCs. Since their return to the United States, more detailed analyses of the data have been possible and have begun to appear. In addition, precision studies of the Antarctic phenomenon will continue for several years or more, seeking quantitative interpretations of all of the data.


NASA

In satellite photo, arrow points to hole in the ozone layer over the South Pole. Scientists are trying to determine if chlorofluorocarbons (CFCs) or other factors are the cause of the Antarctic "ozone hole."

Skin Cancer: The Price for a Depleted Ozone Layer

by Medwin M. Mintzis, MD

Skin cancer has reached epidemic proportions in the United States. It is the most common of all cancers, affecting one out of seven Americans. One-third of all new cancers affect the skin; upwards of a half million new cases are treated each year. This is a 30 percent increase in just 10 years.

The chief culprit in causing this sharp increase seems to be the sun, rather than chemicals and X-rays, and depletion of the stratospheric ozone layer would dramatically exacerbate this disquieting trend in the years ahead.

The ozone layer screens out much of the harmful ultraviolet B light (UV-B) from the sun and prevents it from reaching the earth's surface. But when the ozone layer is depleted, even a one percent increase in UV-B would result in a two percent increase in the number of skin cancers. According to a new EPA study, the number of cases of skin cancer in the next 88 years would total 40 million, with as many as 800,000 deaths if the current trends in use of ozone-depleting chemicals continues.

Skin cancer types are usually categorized in terms of melanoma and non-melanoma. The most dangerous form of skin cancer is malignant melanoma, which arises in the pigment-forming cells (melanocytes). When a melanoma reaches a certain thickness, it spreads rapidly to the vital organs of the body.

In 1986, 23,000 Americans will be diagnosed as having malignant melanoma, and another 6,000 will die of its effects. An individual's lifetime risk for melanoma has soared by 1,000 percent since the 1930s. Currently, one in 150 Americans is expected to develop the disease.

(Mintzis is a member of the Medical Council of The Skin Cancer Foundation and Assistant Professor of Dermatology at New York University School of Medicine.)

Non-melanoma skin cancers—mainly basal cell and squamous cell carcinomas—affect the skin's surface cells. Though often considered "harmless" annoyances, such cancers are far from trivial in their advanced forms. They can result in great disfigurement—the loss of an eye, ear, lip, or nose. And close to 2,000 Americans will die this year because of non-melanoma cancers that spread—or metastasize—throughout the body.

In 1986, 23,000 Americans will be diagnosed as having malignant melanoma, and another 6,000 will die of its effects.

This human devastation need not occur. These cancers are largely preventable. No one should die of skin cancer. The warning signs are there for us to see. When recognized early and treated promptly, skin cancer is 100 percent curable.

The connection between skin cancer and excessive exposure to the sun's damaging rays has been clearly established. In the case of non-melanoma skin cancer, the link is direct. With malignant melanoma, exposure to ultraviolet light is a causative factor, although its precise role is not well understood at this time. Other factors such as chemical carcinogens, oncologic viruses, and genetics may also be involved.

The incidence of non-melanoma skin cancer among the white population in the United States increases as one travels from North to South (that is, closer to the Equator where the daily hours of sunlight are greatest). Studies in Europe and Australia indicate similar patterns. The number of cases of skin cancer doubles with every eight degrees latitude nearer the Equator.

Altitude is also a factor. At greater heights, more UV-B light penetrates the thinner atmosphere. The highest rates of skin cancer incidence in the United States have been found in Albuquerque, New Mexico, which has both a low latitude and a high altitude.

Over 90 percent of all skin cancers occur on those parts of the body normally unprotected by clothing—the face, ears, neck, and backs of the hand. Protruding lower lips, lower eyelids, and ear rims are particularly vulnerable sites.

In temperate zones, people who spend a great deal of their time outdoors—fishermen, farmers, sailors, construction workers, athletes, for example—are the more likely candidates for skin cancer.

Of course, the darker a person's skin, the less likely he or she is to get skin cancer. Blacks and Hispanics are seldom affected; their highly pigmented skin (containing more melanin) is a natural sunblock. Overall, fewer women than men develop basal and squamous cell carcinomas. But among younger people, women develop the disease almost as frequently as men.

The sexes differ somewhat in terms of where skin cancer occurs. Men frequently develop skin tumors on the tips of the ears and on the scalp, areas unwittingly exposed to sunlight by the balding process. On the other hand, women get more cancers on the lower legs—exposed when they wear skirts or dresses—then men. (One may wonder whether current styles of dress will affect the locations of skin cancers in the future.)

Another interesting confirmation of the cancer-causing power of sunlight is that in the U.S., skin cancer is found more often on the left side of the face and arms of men drivers, but in Britain, it typically occurs on the right side of the face. This corresponds to the opposite driving sides in force in the two countries and the amounts of sunlight coming through the open car windows.

Unlike basal and squamous cell carcinoma, melanoma is thought to be related more to intermittent, but intense, bursts of sunlight, than to the total amount of sunlight received over a lifetime. Recent evidence suggests that getting one or more severe sunburns—particularly as a child or a teenager—may increase a person's potential chance of getting melanoma.

As with the other skin cancers, malignant melanoma occurs most often in fair-skinned individuals. Caucasians are affected 10 times more often than blacks. Interestingly, the incidence of melanoma on blacks' non-pigmented skin (the palms of the hands and the soles of the feet) is identical to those areas in whites.

Studies of the influence of latitude on skin cancer in Caucasians reveal, once again, an increased incidence of melanoma closer to the Equator. One study found a connection between the rise of melanoma cases in Scandinavians and the number of cheap charter flights to the south of Spain. Other research has linked the rise in women's hemlines to the development of more melanomas on their legs. On the other hand, melanomas appear more frequently on the chests and backs of

Don Emmench

The sun beating down on his back, a youngster paddles an inner tube on Green Bay in Wisconsin.

Ozone Depletion: Other Health Effects

The link between ultraviolet radiation (UV-B) from the sun's rays and certain skin cancers is well known. As concern has grown release of the science assessment by NASA and the World Meteorological Organization on stratospheric ozone was an important event with regard to our own continuing evaluation process.

Laboratory evidence and case studies demonstrate that exposure to UV-B can harm our immune systems. This finding developed almost inadvertently. Researchers trying to transplant a skin cancer from one laboratory mouse to another found that the cancer would not grow following transplant. However, the scientists found that if they irradiated the second mouse *before* transplanting the tumor, it would take hold and spread. This surprising discovery suggested that UV-B radiation was interfering with the mouse's immune system.

Although we do not understand the exact mechanism by which UV-B suppresses the immune system, further experiments suggest that the implications may extend well beyond skin cancer. Increases in UV-B from ozone depletion may increase the frequency of herpes outbreaks. Leishmaniasis, a disfiguring disease caused by parasites which is widespread in the tropics, may spread more rapidly and heal more slowly. Other diseases may also be affected.

Because the human eye is sensitive to sunlight, we involuntarily blink when we look at the sun. This instinct may be quite protective; laboratory and epidemiological studies show that UV-B is a major cause of cataracts. Cataracts are treatable when caught early, but even in the United States they remain the third leading cause of blindness. In developing countries, they are an even greater cause of blindness.

men than they do in women. The protection against ultraviolet rays provided by different kinds of clothing seems to be a factor.

However, most skin cancers can be prevented if people choose to use a few simple precautions that will minimize the sun's impact on their skin.

In the past, avoiding overexposure to sunlight involved using cosmetically unacceptable opaque barriers or, even worse, resigning oneself to an indoor life style—unacceptable for most people. Today's sunscreen products, developed within the last 10 years, are both effective and cosmetically pleasing. The typical number 15 sunscreen allows for exposure up to 15 times a person's ordinary tolerance to skin reddening.

In addition to regular sunscreen use, a very effective measure is limiting one's time outdoors during the hours of the sun's peak intensity (10 a.m. to 2 p.m. Standard Time or 11 a.m. to 3 p.m. during Daylight Saving Time.) Hats, umbrellas, long pants and sleeves, and tightly woven fabrics are all helpful. These and other simple steps will allow people to protect themselves from skin cancer while enjoying their time outdoors.

Protection from the sun should be practiced from the earliest stages of one's life. All those responsible for the well-being of children and young people—parents, relatives, teachers, babysitters, camp directors, scout leaders, Little League coaches—have a critical role to play in minimizing harmful exposure to the sun's strongest rays.

But for adults with years of chronic, heavy sun exposure, preventing steps may come too late. For this reason, the second major thrust in the war against skin cancer is early detection. In Australia, where a national education campaign against skin cancer was implemented, the debilitating and sometimes lethal effects of skin cancer have been greatly reduced because of widespread public awareness of what warning signs to look for.

The connection between skin cancer and excessive exposure to the sun's damaging rays has been clearly established.

The most common warning sign of an early basal cell carcinoma is a non-healing sore that remains open for several weeks or more. It also frequently resembles a pearly bump, which may eventually develop an ulcer in the middle. At first it may look like a pimple, but unlike a pimple, it does not go away. Sometimes, it appears as a reddish patch or even a scar-like area. Squamous cell carcinoma, which has somewhat similar warning signs, usually appears red and scaly from the start. In time it too may ulcerate in the center.

Malignant melanoma may start in a pre-existing mole or birthmark, or it may develop as a new blemish. Melanomas have four distinct characteristics in contrast to common (benign) moles:

Asymmetry. Some forms of early malignant melanoma are asymmetrical, meaning that a line drawn through the middle will not create matching halves. Common moles are round and symmetrical.

Border. The borders are frequently uneven, often containing scalloped or notched edges. Common moles have smooth, even borders.

Color. Different shades of brown or black are often the first sign of a malignant melanoma. Common moles usually have a single shade of brown.

Diameter. Common moles are usually less than 6 mm. in diameter (¼"), the size of a pencil eraser. Early melanomas tend to be larger than 6 mm.

In addition, melanomas can appear flat on the skin as well as raised. They may also bleed easily.

Itching, pain, or other discomfort is rare with skin tumors, which in part explains why so many people ignore them or delay seeking help.

When detected early, non-melanoma skin cancers are successfully treated with one of several surgical techniques, and less often with freezing of tissue or with radiation therapy. More complicated cases are best treated with microscopically controlled surgery (MOHS surgery), a technique in which each layer of tissue in the removal process is microscopically checked for malignancy.

Malignant melanoma is usually treated by aggressive and extensive local surgery. If, however, it has spread beyond the skin, chemotherapy and/or immunotherapy may be used, although with limited success. Newer experimental immunotherapies such as interleukin-2 and interferon have shown some promise in initial trials in patients with advanced melanoma. Their long-term effectiveness has yet to be shown.

But with skin cancers, as with most diseases, the best treatment is prevention. And that means avoiding the harmful effects of sunlight. □

Ozone Protection: The Need for a Global Solution

by Richard Barnett

Steve Delaney

Some products found in a grocery store, like these foam egg cartons and cups, often are produced using chlorofluorocarbons. CFCs are also used in refrigerators, air conditioners, automobiles, and cleaning solvents.

The potential for ozone depletion and climate change are real environmental concerns. There is ample time to develop effective solutions to address these concerns, but they will require a global focus and the cooperative efforts of industry and government.

Although many substances are thought to contribute to ozone depletion and climate change, attention has focused primarily on a family of synthetic chemicals known as chlorofluorocarbons, or CFCs. A balanced approach to these substances is necessary in order to preserve their valuable uses while limiting any long-term potential for environmental damage.

CFCs were first developed in 1931 as a result of an intensive research effort to identify an efficient, safe refrigerant for home use. They have come to be used in a wide variety of additional applications, the most notable of which are air-conditioning, the manufacture of foam products, and as a cleaning solvent for the electronics industry. The use of CFCs has become widespread because of their many desirable properties. They are non-flammable, non-carcinogenic, non-corrosive, have low toxicity, and are extremely energy efficient.

The contribution of these substances to worker safety and consumer health is substantial. The annual value of goods and services which depend to a varying extent upon CFCs exceeds $28 billion, and more than 780,000 full-time jobs are related to CFC uses in the United States.

(Barnett serves as the Chairman of the Alliance for Responsible CFC Policy and is the Vice President and General Manager of the Central Environmental Systems Division of York International, a large air conditioner manufacturer based in York, PA. The Alliance represents the interests of users and producers of CFCs.)

It is incumbent on us, nevertheless, to examine these substances and their potential for harming the environment in the long-term future. However, we should not rush into short-term regulatory decisions that could result in the use of alternatives that present immediate threats to worker and consumer safety and offer little or no theoretical environmental benefit. In this case, it appears that the penalties of premature regulation could be real in terms of an immediate increase in exposure to more toxic substances or increased energy consumption.

The Alliance for Responsible CFC Policy was organized six years ago to represent the interests of users and producers of CFCs. Alliance members established some basic goals with regard to the ozone depletion theory, CFC usage, and potential government policies.

First, it was our desire to encourage the pursuit of adequate credible scientific research on this important environmental issue, and then to ensure that any government policy be based on the best and most current scientific information.

Second, it was our goal to encourage efforts to resolve this issue in the international arena because of its global scope and to prevent any unproductive, harmful, unwarranted unilateral domestic regulatory program that would injure U.S. industry to the benefit of our international competition.

Third, it was our goal to seek amendments to the Clean Air Act that would provide greater international emphasis on this issue, and give better guidance to the EPA Administrator regarding stratospheric ozone protection activities and the need for regulation.

In the six years that have gone by, we feel that much has been accomplished to obtain our goals, but we believe that much remains to be done.

The United States and many other countries developed scientific programs to understand the ozone layer and the processes that control it. Practically all we know about the stratosphere has been learned in the last 10-15 years. Furthermore, intensive programs to study climate and possible modifications are continuing.

Although the scientific scrutiny has provided considerable information, some of it conflicting, it has also highlighted the many continuing scientific uncertainties. We believe the scientific research must continue.

Additionally, the Alliance has been an active participant in efforts to promote greater international cooperation, as exemplified by our support for the Vienna Convention for Protection of the Ozone Layer, and our participation in such domestic and international efforts to address ozone protection issues as the recently concluded series of workshops sponsored by EPA and the United Nations Environment Programme (UNEP). Given the enormous complexities of the issue, progress—from the scientific and international policy development perspectives—has been remarkable.

In 1980, the Alliance urged that at least three to five years were necessary to allow scientific research to gather critical monitoring information regarding the projections being made by computer models. Therefore, the 1986 release of the NASA/WMO science assessment on stratospheric ozone was an important event with regard to our own continuing evaluation process.

In general, the Alliance does not believe that the scientific information demonstrates any actual risk from current CFC use or emissions. We recognize, however, the growing concern for potential ozone depletion and climate change in the future as a result of large continuing growth of CFC emissions and the buildup of many other trace gases in the atmosphere, and the concern generated by the discovery of unexplained phenomena such as the large reductions in ozone levels during the Antarctic spring.

Scientific progress is not sufficiently developed to tell us that there is no risk in the future. In fact, all of the computer models calculate that large future growth in CFC emissions may contribute to significant ozone depletion in the latter half of the next century.

Therefore, we support further scientific research and believe that regulatory policies should be periodically reexamined in the light of additional research findings.

On the basis of current information, we believe that large future increases in fully halogenated CFCs (the most durable ones, thought to contribute most to ozone depletion) would be unacceptable to future generations. In our view, it would be inconsistent with the goals of the CFC Alliance to ignore the potential for risk to those future generations.

In furtherance of this position, the Alliance recently issued a policy statement which included support for a negotiated global limit on the future rate of growth of fully halogenated CFC production capacity; the development of voluntary programs by industries to conserve CFCs and reduce CFC emissions; and the continuation of research to develop acceptable substitutes for the fully halogenated CFCs.

This policy is significant because it eliminates the "worst case" scenarios being discussed; fosters a continued international cooperative spirit; recognizes the value of CFCs to present day health, safety, and economic concerns of workers and consumers; and will provide some stimulus for the development of CFC alternatives.

The using and producing industries of the CFC Alliance are committed to being active participants in the exploration and the successful resolution of these serious environmental issues; in the promotion of greater global cooperation in conducting the necessary scientific research and monitoring; and in developing coordinated, effective *and* equitable global policy decisions. □

The Saga of Spray Cans


Steve Delaney

Most people probably associate ozone depletion with aerosol spray cans. They remember back to the mid-1970s when public concern peaked that the chemicals given off by hair sprays, underarm deodorants, and shaving creams would deplete the earth's protective ozone shield, leading to increases in skin cancers. Front page stories, editorials, and political cartoons decrying the use of aerosols were widespread. Even Archie Bunker's son-in-law, Michael, in an episode of *All In The Family*, berated his wife Gloria about her continued use of this threat to our well-being.

A decade later, consumers in the United States can go into stores and purchase the same personal products without concern for their effects on ozone depletion.

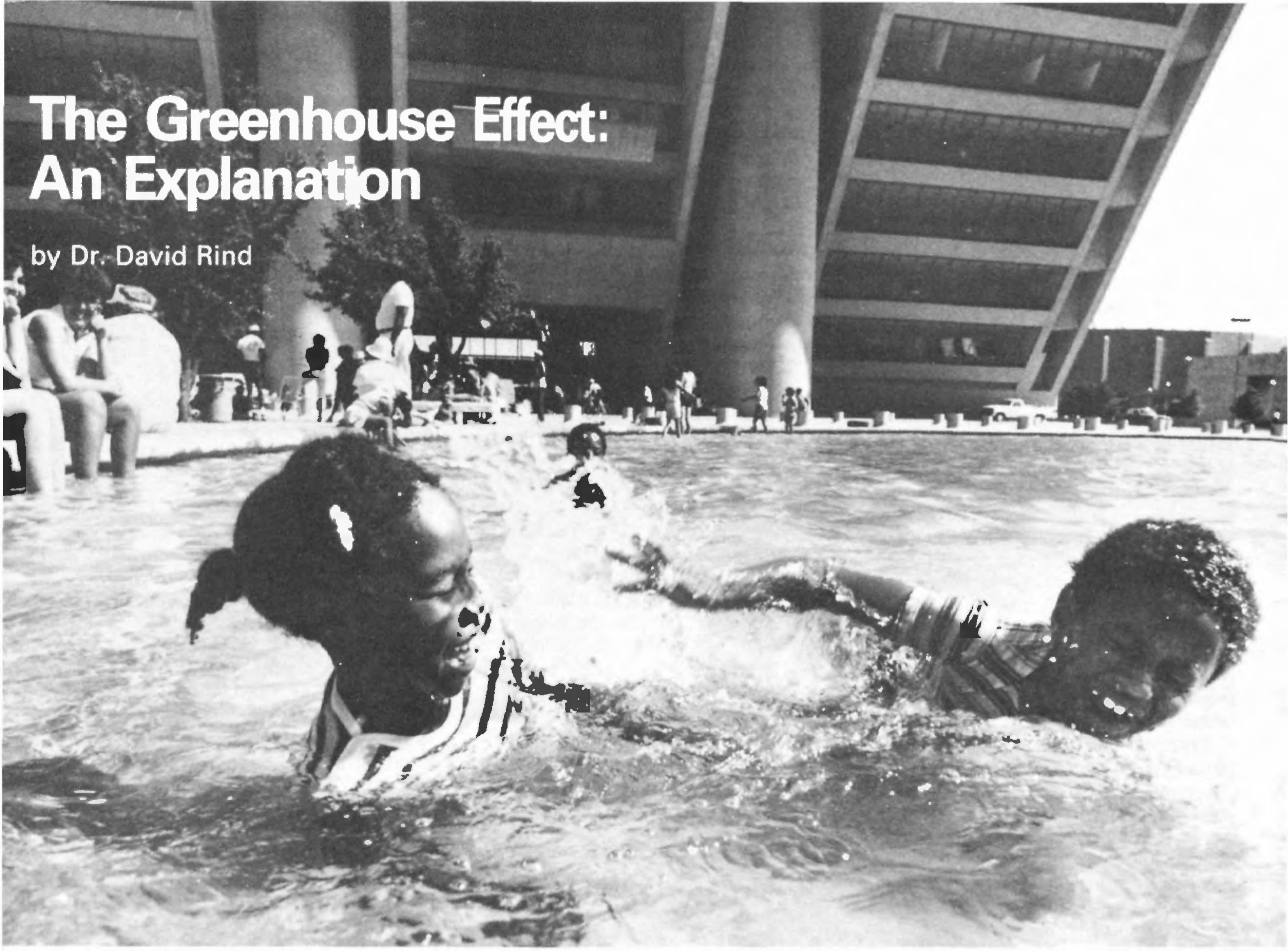
In fact, it was not the aerosols themselves, but their use of chlorofluorocarbons (CFCs) as the propellant which raised concern. Most aerosols contain a statement that they "contain no fluorocarbons." Manufacturers have reformulated their products to use a hydrocarbon propellant system which is safe to the ozone layer.

In response to scientific evidence and public concern, EPA moved to ban CFCs in nonessential aerosols in 1978. But, even before then, the public and manufacturers had shifted rapidly away from these perceived dangerous products. In 1974, CFCs in aerosols accounted for over half of total consumption; by 1978, this use constituted less than five percent. Moreover, consumers still had access to quality aerosol products which, in fact, were less expensive to manufacture than their CFC-propelled counterparts.

By taking action to reduce CFC use in aerosols, the United States and several other nations which followed suit effectively bought a low-cost insurance policy, providing time during which scientific efforts could focus on resolving some of the remaining uncertainties. But, although this action granted some needed breathing room by reducing the rate of growth of CFCs in the atmosphere for almost a decade, that reprieve is over; CFC use has rebounded to match the peak amounts of 10 years ago. This fact, coupled with the recent discovery of the ozone "hole" over Antarctica, has renewed the scientific and the public attention to this issue.

The Greenhouse Effect: An Explanation

by Dr. David Rind



Monte Paulson, Dallas Morning News

The greenhouse effect has caught the imagination of the general populace in the last decade, and the respected, generally conservative scientific establishment has become associated with relatively dire predictions of future climate change. How much is actually known about the greenhouse effect? Can we really establish how climate will change, and when? By separating "hard" science—that which can be verified and is considered well understood—from scientific theory or estimate we can investigate how likely a near-term alteration in climate really is. We explore this subject through responses to a series of questions.

(Dr. Rind is an atmospheric scientist at the Institute for Space Studies, Goddard Space Flight Center, National Aeronautics and Space Administration. He is a leading researcher on aspects of the greenhouse theory of atmospheric warming from manmade gases.)

Do we really understand the "greenhouse" effect?

The greenhouse effect is the name for the physical process where energy from the sun passes through the atmosphere relatively freely, while heat radiating from the earth is absorbed by particular gases in the atmosphere. Although a few uncertainties remain, we can generally calculate very accurately the radiation absorption by different gases. When the concentration of a gas changes, we know how much more energy is being absorbed. This additional absorption by itself warms the planet; for example, doubling the concentration of carbon dioxide in the atmosphere would eventually lead to an increase of the global air temperature by 1.2°C, without any other changes in the climate system. What we do not know, however, is how the rest of the system will react. Current models predict that the warming due to increased carbon dioxide will also increase the evaporation of water vapor from the ocean; because water vapor is itself a greenhouse gas, this will warm the planet further. In addition, as more snow and ice melt in the warming climate less energy from the sun will be reflected back to space (snow and ice are very good reflectors) which promotes further warming. These are examples of "positive feedbacks," and both of these system responses are very likely to occur, although we cannot be sure of the magnitude of the changes. The models also predict that cloud cover will change in such a way as to cause even more warming. Clouds are not yet well understood, and the predicted changes are very uncertain. But the net result of these different processes in the models is to amplify the direct doubled CO_2 warming by more than a factor of three, producing a 4°C temperature rise. Yet it is only the initial greenhouse effect due to increased CO_2, or increases in other trace gases, which we know with great confidence.

On a hot summer day, youngsters cool off in the fountain in front of Dallas City Hall. Dallas currently experiences about 19 days per year of temperatures over 100°F. One estimate indicates that, if current warming trends continue, that number will rise to 78 days by the year 2020.

Can we use the temperatures on other planets to determine what the feedbacks of the system will be?

The atmospheres of other nearby planets validate the general concept of the greenhouse theory, especially in a qualitative sense, but they cannot tell us what the magnitude of the changes on earth will be. Venus, with a massive atmosphere composed essentially of carbon dioxide, has a surface air temperature almost 500°C warmer than would be expected without a greenhouse effect. Mars, with a very thin atmosphere and thus little greenhouse capacity, has an observed temperature close to the expected; and Earth, with intermediate amounts of greenhouse gases, is about 30°C warmer than it would be otherwise. The differences among the planets are very large, and cannot really be used to estimate sensitivity to small changes in greenhouse capacity. Furthermore, as noted above, the big uncertainty lies in the magnitude of the system response, or its "feedbacks"— the most important feedbacks all involve the reaction of processes having to do with water, and the other planets have no freestanding water.

Are greenhouse gases increasing?

An atmospheric monitoring system established in 1958 has measured systematically increasing concentrations of carbon dioxide over the last 28 years. We also believe that concentrations have increased since the turn of the century, although we are less certain about the magnitude of that change. Chlorofluorocarbons are artificially generated gases with greenhouse capacity which are known to be increasing; they have no natural sources, and probably did not exist in the atmosphere prior to the last few decades. Recent measurements indicate that other greenhouse gases, such as methane and nitrous oxide, also are increasing, although we are not sure how long this has been happening. As we are not sure of the reason for their increase, we have less confidence in their long-term trend. In addition, greenhouse gases of which we are only now becoming aware may be increasing, such as some of the more exotic man-made chlorine-fluorine compounds.

Is the temperature record of the past century consistent with this greenhouse gas increase?

Estimates are that the global average surface air temperature has increased by about 0.6°C in the past 100 years; available records are uneven. Temperature recording stations were much less abundant 100 years ago, and large portions of the globe were poorly sampled, especially in the Southern Hemisphere. Even today, full global coverage is not available. The record, such as it is, does not indicate a ubiquitous warming since that time, since the Northern Hemisphere has apparently cooled from the 1940s into the early 1970s. This cooling is inconsistent with the concept of greenhouse warming, but it may be due to other climate perturbations (such as variations in the solar constant or volcanic aerosols) or simply represent internal variability within the system. The overall warming for the past century is the right order of magnitude of the expected greenhouse effect; however, due to uncertainties in the actual temperature change, in the climate feedback factor, in the actual CO_2 amount in 1880, and in the rate of ocean heat uptake (which slows down the atmospheric warming), we cannot be more precise in determining what the expected warming should have been. Similarly, due to the other uncertainties, we cannot use the record to establish what the climate feedback factor really is.

Are current models adequate to allow us to forecast climate change?

Numerical models, called general circulation models, calculate the response of the climate system to the increases in trace gases. The three current models all estimate that the doubled CO_2 climate will have a global average temperature 4°C warmer than today. They are thus all calculating similar climate feedback factors, but as the different models handle many processes similarly, the unanimity does not guarantee accuracy. The treatment of cloud cover in all the models represents a major uncertainty. The models also show differences in the seasonal and latitudinal distributions of the calculated warming. It is unlikely that the models could be wrong by more than a factor of two, but this cannot be proven.

In addition, a climate change forecast should indicate when the warming would be expected to be evident. Only one model (the Goddard Institute for Space Studies [GISS] model) has been used in a time-transgressive mode to calculate the climate for the next 50 years. The results indicate substantial warming in the next decade. This calculation is affected to some extent by uncertainties in ocean heat uptake and the true climate feedback factor. By providing an estimate of how much warming should be observed in the relatively near future, we will have a chance to test the accuracy of these models.

How "dire" is the forecast of coming climate change?

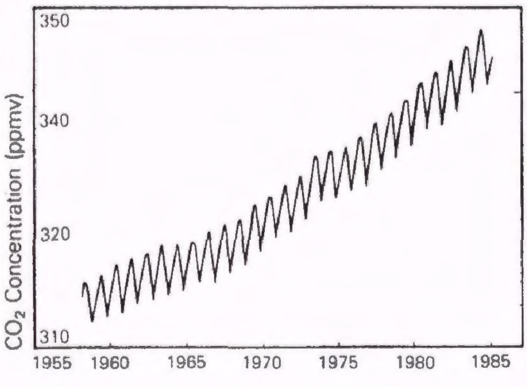
Ice covered what is now New York City during an ice age climate estimated to be some 4°C colder than today's. Considering that the doubled CO_2 climate is estimated to be warmer by the same amount, large changes in the climate system may well be expected if this comes to pass. The forecast for the next 50 years from the GISS model gives changes of 2°C by the year 2020, which would make the earth warmer than it is thought to have been at any point in historical time. Estimates for summer temperatures in the doubled CO_2 climate indicate that Washington, DC, which currently experiences 36 days of temperature above 90°F, would routinely have 87 such days; Dallas would go from 19 days with temperatures above 100°F to 78 days. Sea level rise due to thermal expansion of the oceans would cause severe problems in many coastal cities, and this effect would be exacerbated if additional glacial melting occurred. Rainfall patterns would likely be substantially altered, posing the threat of large scale disruptions of agricultural and economic productivity. The impact of the climate changes predicted by the current models would be immense, and, if the timing is correct, they will come quickly.

Is there any way to prevent these changes from occurring?

The climate is being altered by the release of trace gases due to fossil fuel consumption and industrial processes. These are factors inherent to our current civilization. It is hard to visualize changes sufficient to influence the overall trace gas trend, short of a major catastrophe, although it may be possible to limit specific trace gas increases (such as the chlorofluorocarbons). Our ability to manipulate the climate system deliberately, so as to offset the warming by some other process, is nonexistent. It is likely that the additional greenhouse capacity which has been added during the past 50 years has already built considerable warming into the system, which has not yet been realized due to the slow response of the ocean.

The climate of the next century will very likely be substantially different from today's, and uncertainties in our knowledge of the true climate sensitivity prevent us from knowing exactly how different it will be. The consequences of the estimated climate change would be enormous. With that in mind, it is worthwhile for us to factor climatic changes into our decision-making process, while appreciating the uncertainties that still exist in our understanding. ☐

Carbon Dioxide Concentrations



Measurements of atmospheric levels of CO_2 show a steady seasonal upward trend over the past 30 years. Chart shows levels measured in parts per million in volume.

Hotter or Colder?

Occasionally, predictions have been made that the increasing CO_2 in the atmosphere will lead to another ice age, or that another ice age is coming in any case. Dr. Rind responds:

Most suggestions about increasing CO_2 leading to an ice age involve the effect of climate change on the ocean. Perhaps the presence of warmer ocean water at high latitudes will provide for more precipitation, more snow cover, and the growth of glaciers. Or perhaps the "color" of the ocean will change as ocean warming causes changes in algae concentration, which might increase ocean reflectivity and cool the planet. Or maybe the entire ocean circulation will change, with reductions in the North Atlantic production of "deep water," which is cold salty water that sinks to the bottom. This could force the water that stays on the surface to remain cold.

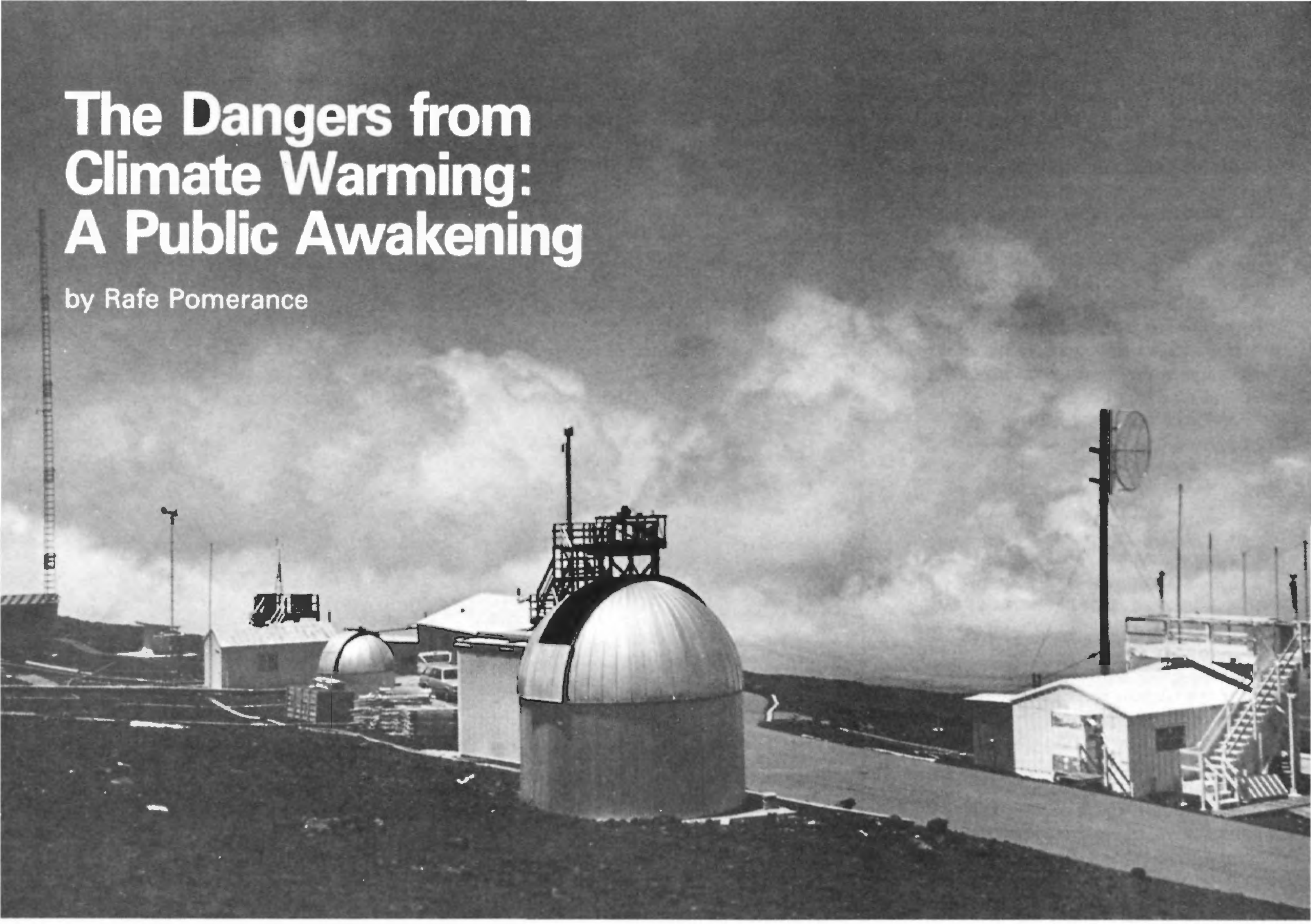
What all these suggestions have in common is that they are highly speculative. The growth of glaciers in a warmer climate, for example, is unlikely because glacial buildup occurs only when temperatures remain below freezing. In most regions of the Northern Hemisphere this does not happen today; and it would be less possible in a warmer climate. If some feedback process initiated by the warming, such as a change in cloud cover or ocean reflectivity, acted to cool the climate, its importance would probably diminish as the warming diminished (for example, cloud cover would return to its current level), and so end the cooling. Finally, while there is some evidence that climate has cooled rapidly in the past during warming episodes, perhaps because of changes in ocean circulation, the event(s) seemed to have occurred when much more extensive land ice already existed, providing cold fresh meltwater runoff for the ocean. Future ocean circulation changes cannot be ruled out, but there is little evidence that they are probable, especially in the near future.

On longer time scales, the likelihood of another ice age is based on the current understanding that ice ages result from variations in the earth's orbit around the sun. At certain periods the earth receives less solar radiation during Northern Hemisphere summer, which would aid in allowing snow cover to persist. The direct solar variation forcing is too small by itself to produce an ice age; the climate system would have to enhance the initial effect in order to produce an ice age. For example, analysis of gas bubbles trapped in ice cores indicates that during ice ages carbon dioxide in the atmosphere is lowered by about 25 percent (about 70 ppm), which would cool the planet. Currently, the orbital variations are such that the solar radiation received in the Northern Hemisphere during summer is decreasing, although it will be several thousand years before it reaches the minimum values which occurred during the last ice age. In this sense we are "going into" an orbital configuration that is more favorable for ice ages.

But the climate change that is our present concern is anticipated to be evident in the next decade, and to reach major proportions during the next one hundred years. Ice ages are lengthy phenomena, occurring over thousands of years, and it is unlikely that major effects would appear on the short time scales of interest here. Furthermore, with a warmer climate it is uncertain whether ice ages could occur: a reduction of 70 ppm of CO_2 today would simply bring the CO_2 level back to what it was normally in the past, well above the ice age values. If minimal CO_2 amounts are necessary for the orbital configuration to generate an ice age, such an occurrence may well be less likely in the future.

The Dangers from Climate Warming: A Public Awakening

by Rafe Pomerance



Mauna Loa Observatory, NOAA

The Mauna Loa Observatory near Hilo, Hawaii, is part of the Geophysical Monitoring for Climatic Change program run by the National Oceanic and Atmospheric Administration. The Observatory's carbon dioxide monitoring records date back to 1958.

"A Dire Forecast for Greenhouse Earth" *The Washington Post*

"Swifter Warming of Globe Foreseen" *The New York Times*

"The Silent Summer, Ozone Loss, and Global Warming: A Looming Crisis" *Newsweek*

(Pomerance is Senior Associate for Policy Affairs at the World Resources Institute.)

"The greenhouse effect"...this term is part of the public vocabulary now. In just a few years, it has changed from a scientific curiosity to a major policy issue for industries and governments all over the world.

Why? How did a question of seemingly academic interest suddenly become the subject not only of headlines and talk shows, but of government hearings and international negotiations?

Simply put, the greenhouse effect is the process in which heat radiating from the earth's surface is trapped by gases, such as carbon dioxide and methane, in the atmosphere. The increased heat results in a rise in global temperatures which may significantly alter climate patterns. Scientists have known and studied this effect for decades, but only recently have they reached the fundamental consensus that rising levels of greenhouse gases may threaten the future of our planet. Now the implications of that possibility are reaching governments.

The greenhouse effect reached a new stage in its evolution as a policy issue in 1979, when four eminent scientists reported to the Council on Environmental Quality (CEQ) that "...man is setting in motion a series of events that seem certain to cause a significant warming of world climates unless mitigating steps are taken immediately." The authors were ecologist George Woodwell, one of the first to examine the role of deforestation in the buildup of carbon dioxide; geophysicist Gordon MacDonald, one of CEQ's original members; David Keeling of the Scripps Institute of Oceanography, who coordinated continuous measurements of carbon dioxide in the atmosphere; and oceanographer Roger Revelle, who established the carbon dioxide monitoring station at Mauna Loa in Hawaii in 1957 and who chaired the

1977 National Research Council report, "Energy and Climate."

At about the same time, the National Academy of Sciences also began a study of the greenhouse effect. After reviewing available atmospheric models and analyses of past climates, the study chaired by meteorologist Jule Charney concluded that "We have tried but have been unable to find any overlooked or underestimated physical effects that could reduce the estimated global warming due to a doubling of CO_2 (carbon dioxide) to negligible proportions or reverse them altogether." The study estimated that a doubling of CO_2 in the atmosphere would raise global temperature by 3°C, plus or minus 1 1/2°C.

The greenhouse problem was debated in yet another forum that year when the Carter administration proposed a major synthetic fuels initiative. In *The Washington Post*, Gordon MacDonald argued that synthetic fuels produced even more carbon dioxide per unit of energy than coal, oil, or natural gas. MacDonald warned that subsidizing synthetic fuels was a mistake that would only increase U.S. dependence on CO_2 intensive energy systems.

The controversy attracted the interest of then U.S. Senator Abraham Ribicoff, who had recently been warned of the greenhouse effect by West German Chancellor Helmut Schmidt. Ribicoff convened a Senate symposium on the subject. The result was an amendment to the synthetic fuels legislation of 1980 mandating that the National Academy of Sciences undertake another, comprehensive, review of the problem. Also in 1980, the National Commission on Air Quality held a workshop on the greenhouse effect as part of its review of the Clean Air Act. That workshop may have been the first study to concentrate solely on public policy issues rather than science aspects of the problem.

In January 1981, under the leadership of Gus Speth, the Council on Environmental Quality released its report on the CO_2 problem. After analyzing the reductions in CO_2 emissions that would be needed to keep levels below 1 1/2 times preindustrial levels, CEQ concluded that "the potential risks from even moderate increases in the burning of fossil fuels...underscores the vital need to incorporate the CO_2 issue into the development of United States and global energy policy." Adding a major dimension to the problem, scientists at the Goddard Institute of Space Studies concluded later that same year that CO_2 was not the only problem gas; methane, tropospheric ozone, nitrous oxides, and chlorofluorocarbons (CFCs) could also contribute significantly to warming the atmosphere.

The Environmental Protection Agency made its first contribution to the debate in 1983, when it released its report "Can We Delay a Greenhouse Warming?" EPA's report concluded that levels of atmospheric greenhouse gases were already high enough to trigger a global warming, and that economic momentum would ensure even further warming.

Based on his climate models, Hansen projected that significant warming might be observed within five to 15 years.

The report further concluded that global temperatures would rise by 2°C within a relatively short time, even with major reductions of CO_2 emissions, although such reductions could have an impact in the long run.

EPA's report was followed shortly by *Changing Climate*, the greenhouse study of the National Academy of Sciences. In contrast to EPA's conclusions about fossil fuel use and CO_2 buildup, the Academy judged that "We do not believe that the evidence at hand about CO_2-induced climate change would support steps to change correct fuel use patterns away from fossil fuels."

Perhaps the Academy report calmed public fears. At any rate, the issue faded from the public eye until 1985, when new scientific information, a key international conference, and a series of Congressional hearings combined to return the greenhouse effect to public awareness.

Early in 1985, scientists V. Ramanathan and Ralph Cicerone and their colleagues from the National Center for Atmospheric Research announced that not only were other greenhouse gases contributing as much to global warming in the 1980s as CO_2, but also that these gases could eventually surpass carbon dioxide in their contribution to the greenhouse effect. These findings reinforced the growing consensus that some global warming was inevitable and that it would occur rapidly.

An international meeting in October 1985 came to the same conclusion. Under the auspices of the United Nations Environment Programme and the World Meteorological Organization, scientists from 29 nations met in Villach, Austria, and agreed that "some warming of climate now appears inevitable; the rate of future warming could be profoundly affected by government policies on energy conservation, on use of fossil fuels, and emission of some greenhouse gases."

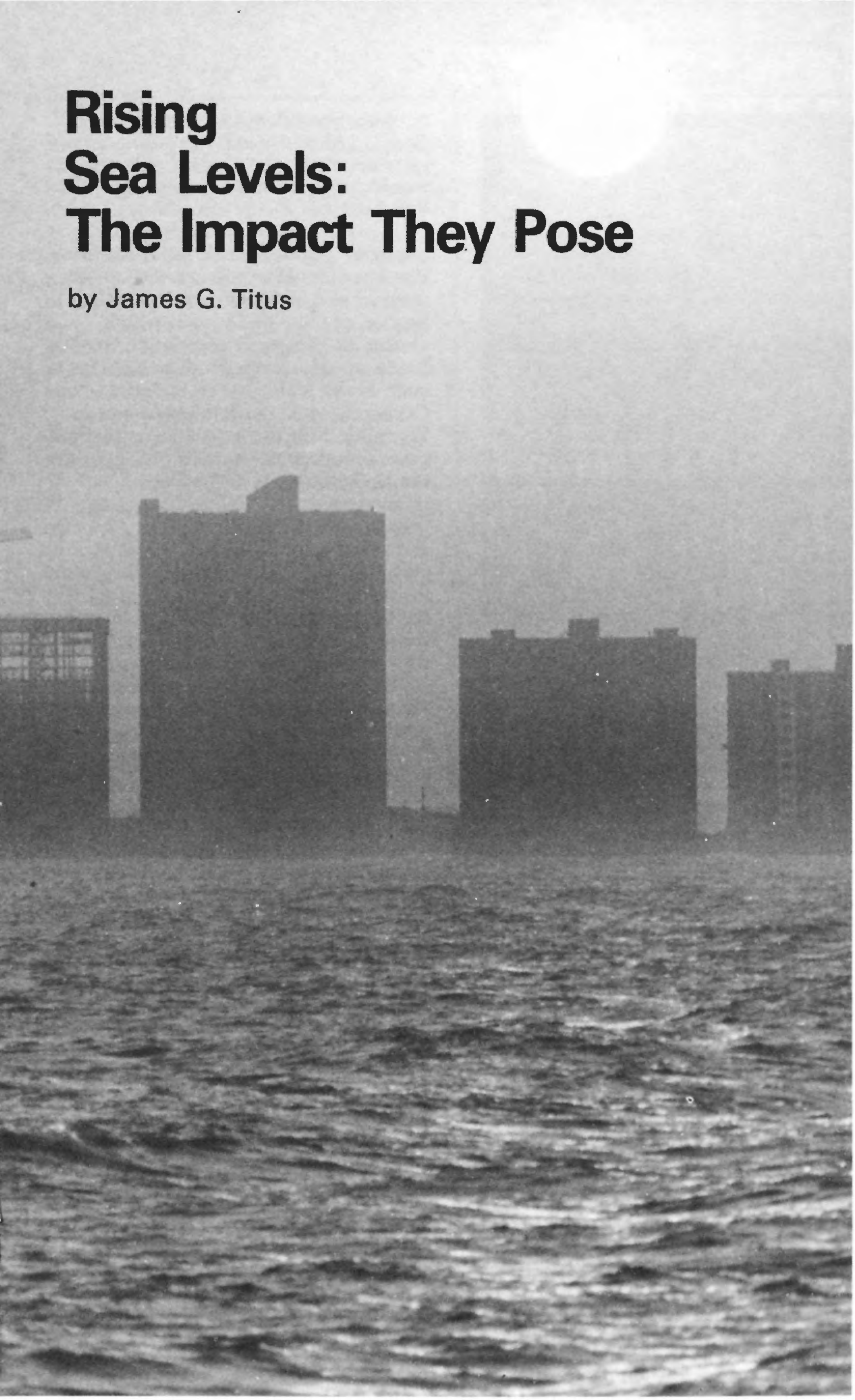
Following on the heels of the Villach conference was a Senate hearing convened by Senator David Durenberger, as well as a call by Senator Albert Gore for an international "Year of the Greenhouse" to focus attention on the problem. Gore was not new to the issue, having conducted hearings on the greenhouse effect in 1982 and 1984 while he was a member of the U.S. House of Representatives. The pace quickened in 1986, when the World Meteorological Organization, the National Aeronautics and Space Administration, and numerous other agencies issued a three-volume report on atmospheric ozone. The report detailed the rapid atmospheric changes occurring as a result of human activity, particularly the greenhouse effect and the depletion of the protective ozone layer in the stratosphere. Concluded the report, " There is now compelling evidence that the atmosphere is changing on a global scale." Finally, Senator John Chafee's hearings in June of 1986 brought together key scientists and government officials to discuss the problem. Perhaps the most significant testimony came from Dr. James Hansen of the Goddard Institute for Space Studies. Based on his climate models, Hansen projected that significant warming might be observed within five to 15 years.

This was a surprise to many observers. The greenhouse problem had been viewed as taking decades to develop, and, indeed, doubled levels of carbon dioxide in the atmosphere were still projected to occur decades from now. It was the possibility that warming could occur at much lower levels of CO_2 that suddenly became a serious issue for government policymakers to address.

The Chafee hearings raised the visibility of the greenhouse issue, making it a more likely factor in policy discussions. Senator Chafee moved the issue another step by asking EPA to develop a set of policy options for stabilizing the level of greenhouse gases in the atmosphere. When completed, this study should mark the beginning of another era for the greenhouse effect and the problem of global warming. □

Rising Sea Levels: The Impact They Pose

by James G. Titus



Steve Delaney

High-rise condominiums line the beach in Ocean City, MD. Beach erosion due to rising sea levels could threaten many resorts with buildings close to shore. In Ocean City, officials have already tried rebuilding eroding beaches by bringing offshore sand onto shore.

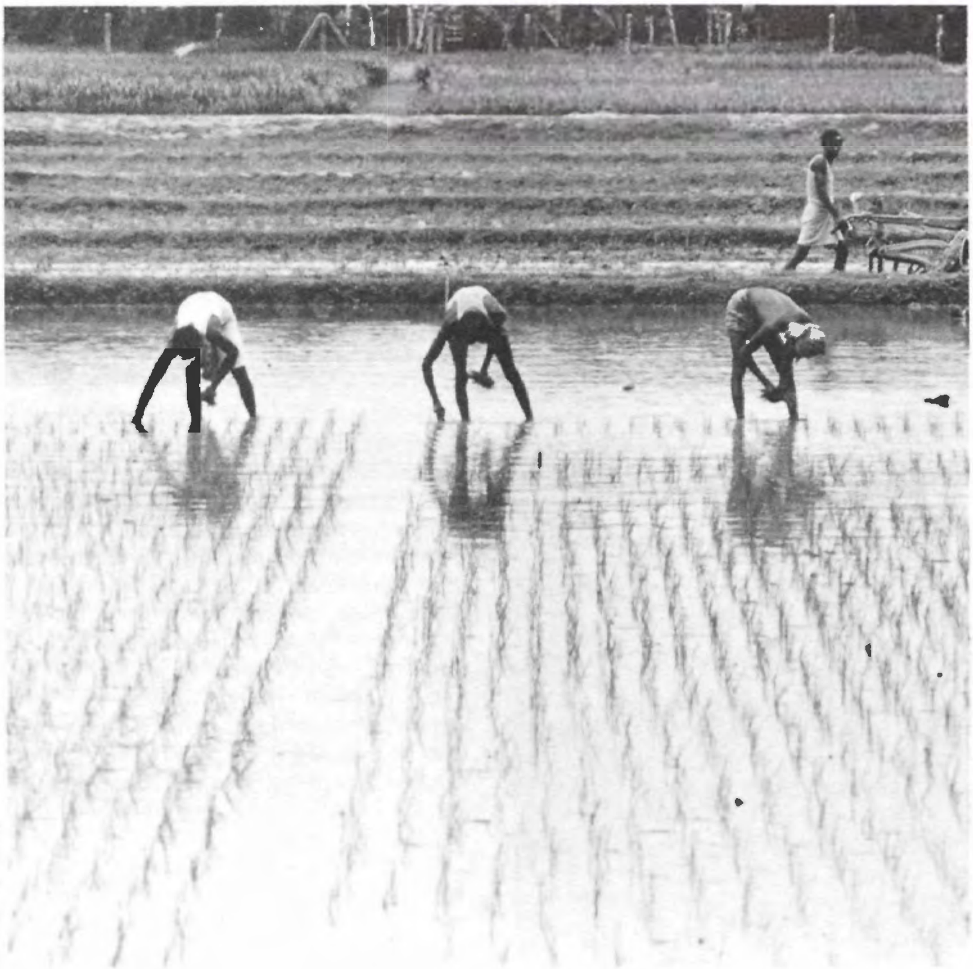
(Titus is Project Manager for Sea Level Rise in the Office of Policy Analysis in EPA's Office of Policy, Planning, and Evaluation.)

For the last several thousand years, the level of the oceans has risen so slowly that for most practical purposes it has been constant. This slow rate of rise has made it possible for ecosystems and human activities in coastal areas to develop more extensively than would otherwise be possible. Whether one is looking at an Ocean City or Rio de Janeiro beach resort, swamps in Louisiana, farmland in Bangladesh, marshes along the Chesapeake Bay, or the merchants of Venice, life along the coast is in a sensitive balance with the level of the seas.

This balance may be upset by the global warming that is expected to result from the "greenhouse effect" projected by atmospheric scientists. Climatologists generally expect that if human activities continue to release carbon dioxide, chlorofluorocarbons, and other gases that absorb infrared radiation, average temperatures on our planet will rise four to nine degrees (F) in the next century. This global warming could raise sea level one foot in the next 40 years, and two to six feet in the next century. The rising seas could inundate low-lying areas, erode beaches hundreds of feet or more, increase the risk of flooding in coastal areas, destroy coastal marshes and swamps, and increase the salinity of rivers, bays, aquifers, and water supply systems.

By "sea level" we mean the average water level of the oceans, coastal estuaries, tidal rivers, and bays throughout the course of a year. In the last two million years, sea level has been three to five hundred feet lower during ice ages than it is today. During warm "interglacial" periods, sea level has been at approximately today's level. But during the last interglacial period one hundred thousand years ago, the level was about 20 feet higher than it is currently.

The main reason sea level has fluctuated so much is that during ice



World Bank photo by Thomas Sennett

Farmers transplant shoots in a Bangladesh rice field. According to one estimate, a six foot rise in sea level would flood about 20 percent of Bangladesh.

ages much of the northern hemisphere was covered with an ice sheet thousands of feet thick. As those glaciers melted at the end of the ice ages, the water flowed back into the oceans and the sea rose. From around 15,000 B.C. until around 5,000 B.C., sea level rose about three feet per century. Since then, the sea has risen only an inch or two per century on average. However, tidal records show that in the last hundred years it has risen four to six inches.

Although most of the ice sheets covering North America during the last ice age have melted, the expected global warming could raise sea level for a number of reasons:

- **Thermal expansion.** Ocean water expands when it is heated, which could raise the sea level a foot or two in the next century.
- **Alpine glaciers.** The snow covering various mountains throughout the world could melt, adding another foot to sea level.
- **Greenland.** Polar scientists estimate that glacial melting there could add another foot to sea level in the next century.
- **Antarctica.** Over the next two hundred to five hundred years, it is possible that the West Antarctic Ice Sheet could completely disintegrate, which would raise sea level 20 feet. Fortunately, polar scientists generally believe that Antarctic glaciers are unlikely to contribute more than three feet to rising sea level in the next 100 years.

Several scientific groups—the U.S. National Academy of Sciences, the Environmental Protection Agency, and an international conference in Austria sponsored by the United Nations Environment Programme—have estimated the future rise in worldwide sea level. The consensus for the most likely rise in the next century is in the range of between two and six feet, with a one-foot rise possible in the next 40 years. Because much of the U.S. coast is sinking, the rise along most of the Atlantic and Gulf coasts in the next century will be six to eight inches greater.

The major anticipated impacts of sea level rises are inundation, erosion, increased flooding, and saltwater intrusion. Areas that are now just above sea level will be inundated. A six-foot rise in sea level would flood about 20 percent of Bangladesh, and a similar portion of the Nile Delta in which almost all of Egypt's population resides. Some island nations built on coral reefs such as the Maldives in the Indian Ocean could be entirely under water. Were it not for the extensive network of dikes and drainage canals, one-half of the Netherlands would also be threatened.

In the United States, most areas just above sea level are coastal marshes and swamps, which are extremely important for the survival of many types of birds, fish, and furbearing animals. Because wetlands have been able to keep pace with the slow rates of sea level rise that characterized the last few thousand years, the area of wetlands is generally greater than the area just above sea level. If the sea should rise more rapidly in the future, a very large loss of those wetlands could result, even though new wetlands would form as inland areas are inundated. If the adjacent upland areas are developed, all the wetlands could be squeezed out. Recent estimates suggest that a three- to six-foot rise could destroy 50 to 80 percent of U.S. coastal wetlands.

The coastal wetlands of Louisiana—which account for almost half of U.S. coastal wetlands—appear to be particularly vulnerable to a rise in sea level. These marshes and swamps were formed by sediment washing down the Mississippi River. Although the muds sank two or three feet per century, annual flooding provided more than enough additional sediment for the subsiding wetlands to keep pace with relative sea level rise. However, in the last century, human activities have diminished the ability of the Mississippi delta to keep pace with sea level rise. Flood control levees and navigation channels confine the flow of the river so that the sediment no longer reaches the wetlands; it is now shunted off the edge of the continental shelf into the deep waters of the Gulf of Mexico. As a result, Louisiana loses 50 square miles of wetlands per year to the sea. Unless major efforts are undertaken to restore some of the natural processes, the projected rise in sea level will accelerate the drowning of wetlands and most of this valuable ecosystem will be lost in the next century.

Along the open coast, a rise in sea level causes the shore to retreat considerably beyond the part of the beach that is inundated. Higher water levels enable storm waves to strike further inland to erode more of the beach, and decrease the ability of calm waves to rebuild the beach. Along most of the U.S. coast, a one-foot rise in sea level will erode 100 to 200 hundred feet of beach. This could threaten many resorts that have buildings within 100 feet of the shore.

A rise in sea level could increase coastal flooding for three reasons. First, during hurricanes and northeasters, "storm surges" can raise water levels five to fifteen feet higher than normal, providing a higher base for these surges to build upon. For example, in Charleston, SC, areas that today are flooded only once a century would be flooded every 10 years if sea level rises five feet. Second, erosion can leave particular properties closer to the shore and thus more vulnerable. Finally, higher water levels decrease the efficiency of natural and artificial drainage systems, causing backwaters that can increase flooding from rainwater.

Sea level rise also increases the salinity of ground and surface waters in coastal areas; this can cause important shifts in coastal ecosystems. Although fresh water marshes may be replaced by salt marshes, freshwater cypress swamps are generally converted to shallow lakes when exposed to excessive salinity levels, which is already occurring in Louisiana. Saltwater intrusion also threatens drinking water supplies. A two-foot rise in sea level would result in Philadelphia's Delaware River water supply being too salty to drink during droughts when streamflow is diminished. Moreover, because the aquifers on which suburban New Jersey relies are recharged by the (currently fresh) Delaware River, increased river salinities could result in salty river water contaminating the aquifers.

How can the impacts of rising sea level be prevented or at least ameliorated? Society can respond to these problems either by reacting to them as they occur or by anticipating them as part of the planning and design of coastal communities and other long-term projects. The most general response to ameliorating the problem of sea level rises would be to limit emissions of greenhouse gases and limit the acceleration of sea level rise. But such a policy is only likely to be effective if implemented long before problems emerge, because it would take a few decades to carry out. Even if all emissions were curtailed, the earth would continue to warm for at least a few decades as the oceans came into equilibrium, after which the sea would continue to rise for at least a few more decades as glaciers came into equilibrium with the higher temperatures. By the time the sea rises one foot, it would be too late to prevent a several-foot rise in sea level.

Therefore, coastal communities must also look at ways of adapting to whatever rise does take place. Possible responses to inundation, erosion, and flooding will fall broadly into three categories: building walls to hold back the sea, raising the land surface, and retreating from the shore.

Levees and dikes are already used to hold back the sea to protect areas below sea level in the Netherlands and adjacent countries, as well as such U.S. cities as New Orleans and Texas City. This option will probably be the preferred response for most major low-lying metropolitan areas. However, it will not be appropriate for coastal barrier islands whose recreational beach economies require that the shore be a beach, not a wall. Moreover, this option can result in a complete loss of coastal wetlands. For communities built on coral reefs, levees may not be able to keep the water out.

Raising the land surface may be the preferred option for coastal barrier island resorts such as Miami Beach, where property values are high and there is a need to maintain a recreational beach. For communities on coral reefs, this may be the only option. This method may also be the only way to simultaneously protect wetlands and coastal property; however, technologies to accelerate the ability of wetlands to grow upward are expensive and not entirely proven. Nevertheless, raising the land surface is already employed in many coastal areas where dredges pump sand from offshore to rebuild eroding beaches.

In some cases, property values may not be great enough to justify construction of a levee or raising the land. In other cases, defending the shore may be economically viable, but the social goal of protecting natural shoreline environments may preclude those options. In these instances, the only alternative will be to adapt to a retreating shoreline.

If the current shoreline is to be

Greenhouse Effect: Other Impacts

The greenhouse effect may well shift our climate to conditions unknown in recorded human history. While our ability to predict the full implications of this shift is limited, one approach is to study the earth's past for clues to its future. Based on geological studies of life thousands of years ago, we know that many aspects of our environment are intertwined with climate. They have undergone dramatic changes, particularly compared to 18,000 years ago when the earth was about five degrees Centigrade cooler.

As the earth warms, we may see changes in all aspects of our climate: changes in rainfall patterns, more frequent storms, and more extreme temperatures. As a result, agriculture and natural ecosystems will be affected. Important changes in farm productivity can be expected throughout the world. Crops that now prosper may not grow, and today's breadbaskets may become tomorrow's dust bowls. The need to develop new agricultural methods and crops, perhaps through advances in bioengineering, will pose a critical challenge to future generations.

The makeup and extent of our natural ecosystems, including wetlands and wilderness areas, may shift. As mild-latitudes warm, evergreen forests may be forced to shift north. If human development blocks this migration, the entire ecosystem may be at risk. The implications for endangered species, many of which are adapted to specific environmental niches, may also be severe.

Climate change will affect the availability of water for industrial and agricultural uses, and for drinking. As rainfall patterns shift, reservoirs may dry up, or dams become overburdened. The water projects we build today will last 50 years or more. They are designed with the assumption that tomorrow's climate will be the same as today's—an assumption that may not hold as greenhouse gases build up in the atmosphere.

The implications of climate change are broad. The weather, a mainstay of conversation today, is likely to take on a growing importance as the world warms.

Kenner Rice, USDA Soil Conservation Service

Flood damage in Virginia Beach, VA. A rise in sea level could increase flooding in coastal areas like this.

maintained, there is little advantage to defending it before the sea rises enough for defensive efforts to be necessary. However, retreating from the shore would require considerable lead time, since coastal structures can last 50 to 100 years and their owners would be reluctant to move or abandon them. This need for advance planning has been incorporated into many state coastal zone plans, which require that new construction be set back from the ocean shore a distance equal to the erosion expected in a given number of years. North Carolina requires houses that can be subsequently moved to be set back from the shore to a point approximately "30 years worth" of erosion and large buildings to be set back "60 years worth." In Maine, the set-back requirement is 100 years. However, these regulations do not yet incorporate the degree of shore retreat that might be necessitated by the accelerated rates of sea level rise that are now expected.

The need for advance planning may be even greater in the case of wetland protection. If the problem is not addressed until the sea has risen significantly, it may be too late to require development to retreat without costly purchases of land and structures. By contrast, long-term planning could help ensure that new structures are not built in areas where new wetlands are likely to form.

Long-term planning for saltwater intrusion into water supplies may also be useful. For example, in the case of the Delaware River, the water authorities maintain reservoirs and release fresh water when salinity levels increase. Sea level rise may require more reservoirs in the future. While there is no need to build those dams today, now is the time to identify the locations where they would be built if needed. Otherwise such sites may be developed for other uses precluding the options by which future generations can address the problem.

Fortunately, most of the consequences from the expected rise in sea level are still decades in the future. Why should we focus on these future problems when we are faced today with more immediate problems such as toxic waste dumps, urban smog, and dying estuaries? Former EPA Administrator William Ruckelshaus offered this perspective:

> *Our system of government has traditionally been biased toward a sort of institutional inertia, which is eventually broken by development of a massive consensus. The problem is that in our ultimate haste, we may not give adequate attention to all the options. Whether we can continue in such a manner is a subject open to question...in an era producing catastrophes of a magnitude greater than in the past, we can place our institutions in situations where precipitate action is the sole option—and it is then that our institutions can be imperiled and individual rights overrun.*

When, as in the case of the greenhouse effect and the rising seas, a period of several decades must pass between cause and effect, the future environmental problems should be addressed as they are being created, rather than waiting until their consequences are upon us.

Other nations are also beginning to examine the implications of future sea level rise. For example, in August 1986, a conference of 50 scientists and officials from around the Soviet Union sponsored by the Estonian Academy of Sciences recommended that decision makers be informed about "the cost of designing new facilities for a future rise compared with the cost of rebuilding the facilities if such a rise takes place." Professor Eric Bird, an invited observer from Australia, expects these recommendations to be acted upon: "The Soviets have a track record of implementing the recommendations of this panel."

Addressing the causes of sea level rise will require nations to work together. But individual nations and communities and individuals can decide for themselves whether and how to prepare for and react to the effects and, in so doing, will help create the understanding and public awareness necessary to address the causes. ☐

Ill Winds Carry No Visas

by Dr. Mostafa K. Tolba

United Nations photo by M Grant

Dr. Mostafa K. Tolba

It took just one "isolated" incident recently to bring this moral home to the world public. The Chernobyl catastrophe showed us that nuclear accidents do not discriminate in their terrible costs. Fallout respects no national boundaries when it follows the winds, and radioactivity obeys no laws but those of science. Never has the need for international cooperation on global environmental problems been more graphically illustrated.

The growth of technology in the past 50 years has brought us—indeed, bound us—together through international trade, travel, and communications. But these same advances also have entirely new environmental consequences, including major impacts on the earth's protective blanket of atmosphere. Along with its benefits, technology has the power to alter Earth's conditions to something never experienced in human history. A single nation's activities may now directly affect not just global politics or economics, but also the very biological and atmospheric bases of the planet. Nobody knows how these modifications will ultimately shape our planet, but they surely will change our lives.

The "greenhouse effect," for example, is already altering world climate by trapping heat within the atmosphere, a phenomenon with serious implications for rising sea levels and altered weather patterns across the globe. And in the upper atmosphere, emissions of chlorofluorocarbons (CFCs) and other compounds may be destroying the protective layer of ozone that shields Earth and its inhabitants from harmful solar radiation. Scientists predict a staggering rise in fatal and other skin cancers because of increased ultraviolet radiation over the next century, as well as other impacts on human health and damage to agriculture, water resources, forestry, and wetlands.

Not all the winds of technological change need be ill winds. Someday, we may be able to use our newly recognized power over the climate and atmosphere in constructive ways, perhaps by preventing droughts or by diverting typhoons away from inhabited areas. But that is a distant prospect. We must first begin to repair the damage that is occurring already. And we can only hope to succeed in that task by working together.

First Steps

Although most of the world's people are not responsible for the technologies that cause problems such as ozone layer depletion, the majority of them have benefited to some extent from the products of such technologies. And everyone shares the risks posed by their byproducts. These risks may vary with many factors, but the fact remains that we must all share equally the responsibility for protecting the world's environment from further damage.

The 1985 Vienna Convention for the Protection of the Ozone Layer is one of the first fruits of this global environmental ethic. By calling for an international framework for controlling CFCs, the signatories not only agreed to work on problems which only a handful among them had caused; they also established a model for anticipating and avoiding other worldwide environmental problems.

The road to Vienna was not entirely smooth. By all conventional tests, CFCs appear unimpeachable. They are non-toxic, non-flammable, and among the most useful and least wasteful refrigerants and foam-blowing agents available to modern industry. It required careful monitoring and study by UNEP (the United Nations Environmental Programme) and others to make the case for the role of CFCs in ozone depletion. And without the research and action that led to Vienna, CFC emissions might still be increasing without the slightest suspicion of their damage to the ozone layer and hence to human health. How many millions of people might have suffered skin cancers and eye damage before the connection with CFC emissions was made?

Nor is the Vienna Convention the end of the road. The details for controlling CFCs internationally still need to be hammered out, and it is still difficult even to measure changes in the ozone layer. The only certainty is that concentrations of trace gases in the atmosphere are increasing. It is not impossible that the consequences of CFC emissions may be less disastrous than we fear. But only time will tell.

In the meantime, the Vienna Convention provides an international legal instrument to ensure that appropriate action is being taken. UNEP is guiding negotiations to decide how best to protect the ozone layer, for example through production quotas, emission reductions, or end-use controls on manufacturing processes. By mid-1987, we hope these negotiations lead to provisions in the Convention that incorporate fair and effective, yet flexible channels for limiting ozone damage.

The Next Challenge

The next great challenge for UNEP is to convince the international community to apply the lessons of the Vienna Convention to the related issue of greenhouse gases and their impact on world climate.

It will be difficult. We already know that this impact varies far more from region to region, or latitude to latitude, than does that of ozone depletion. There will be winners and losers because of this variation, but winning and losing will be unrelated to polluting activities. Like ozone depletion, the problem is irrefutably a world problem.

UNEP has already taken the vital preliminary steps for a global solution. We are seeking the support of other United Nations agencies and other governments and non-government organizations for a more responsible attitude towards the environment, a commitment to development without destruction. Achieving this will require the timely assessment of potential impacts, and the development of frameworks for international collaboration to reduce or eliminate damage through swift, practical action.

We may be able to save the ozone layer now, thanks to the Vienna Convention and the fusion of will, effort, and resources that made it possible. International cooperation for the environment has gained a solid precedent, a new assurance that it can be done.

The hopeful future opened up by this achievement offers a breath of fresh air after the ill wind of Chernobyl. We may even take some strength from it. For the sake of the victims of that tragedy and their grieving families, let us hope so. □

(Dr. Tolba is Executive Director of the United Nations Environment Programme and a leading figure on global environmental issues.)

Finding Answers

by John H. Chafee

NASA

A spaceship view of Earth. Problems of ozone depletion and the greenhouse effect "are dramatic new reminders that we live on a vulnerable planet."

(Senator Chafee, R-R.I., is a senior member of the U.S. Senate Environment and Public Works Committee and from 1981 to January 1987 chaired the Subcommittee on Environmental Pollution. In June 1986, he chaired a series of hearings on upper atmosphere problems.)

Although the problems of stratospheric ozone depletion, the greenhouse effect, and climate change have not yet reached the same level of public recognition as toxic waste or acid rain, more and more people are becoming aware of and concerned about them. The coverage that these issues has received in the past few months is evidence of this. Across this country, Canada, and Europe, there have been stories and editorials in newspapers, on national television and radio, and in magazines such as *Newsweek* and *The New Yorker*.

These problems—and the international interest in them—are dramatic new reminders that we live on a vulnerable planet, and that, if we do not think and act in consort, we may indeed perish in consort.

In June 1986, the Senate Subcommittee on Environmental Pollution conducted two days of hearings to explore the nature of these problems and to examine what is being done by the U.S. government, domestically and internationally, to both improve our understanding of these matters and to respond to them.

Why did we decide to spend time on these problems? Why is all of this so important? Why are policymakers demanding action before scientists have resolved all of the questions and uncertainties?

We are doing so because there is a very real possibility that man—through ignorance or indifference, or both—is irreversibly altering the ability of our atmosphere to perform basic life support functions for the planet.

This is not a matter of Chicken Little telling us the sky is falling. At our hearings, we heard graphic, powerful, and disturbing testimony from distinguished scientists. The scientific evidence and the international consensus is that we have a problem, a serious problem. We already know a great deal, and there is a great deal more that we can predict with relative certainty.

It is true that we lack the tools to close all of the scientific gaps. We don't completely understand our climate systems, nor can we predict precise regional outcomes. But we will always be faced with a level of uncertainty. Scientists have characterized our response to the greenhouse effect as a global experiment. It strikes me as a form of planetary Russian roulette.

We should not be experimenting with Earth's life support systems unless we are sure that the results will be benign. In a statement that serves as a powerful reminder of a basic concept, Russell Peterson, chemist and former chairman of the President's Council on Environmental Quality, has said, "we cannot afford to give chemicals the same constitutional rights that we enjoy under law...chemicals are not innocent until proven guilty."

By not making policy choices today, sticking to a "wait and see" approach, we may in fact be choosing by default. By allowing the so-called "greenhouse" gases to continue to build up in the atmosphere, this generation may be committing all of us to severe economic and environmental disruption without ever having decided that the value of "business as usual" is worth the risks.

Those who believe that these are problems to be dealt with by future generations are deluding themselves. Our activities may already have committed us to some level of temperature change. If historical evidence is any guide, even a slight warming may be enough to turn productive, temperate climates into deserts. To quote from a recent Department of Energy report, "large changes in both precipitation and the extent of deserts and grasslands can be associated with relatively small variations in the global mean temperature."

Society's course today is much like a car being driven towards the edge of a cliff. We can go ahead, take no action, and drive off the edge. Or we can put the brakes on now, before the car gets any closer to the edge of the cliff and before momentum takes us over the side. We have a choice.

The question is: How do we make it?

First, it is important to focus attention on the potential effects of ozone modification and climate change. Simply telling people there will be a change is not enough. They need to understand how they will be affected by it.

In addition, we must begin to consider the choices that must be made if we are going to avoid further buildup of harmful gases in the atmosphere. All of us must recognize that these are no longer just science issues. They are now policy issues. They demand solutions.

Many of the government witnesses who appeared before my Subcommittee last summer argued that we need more studies. They contend that there are too many scientific uncertainties to warrant action.

Sure, we can continue to study the problem—and we should continue our studies—but we cannot wait until these studies are completed. We need action.

Only Lee Thomas recognized what is at stake here. He was the only decisionmaker from the government who appreciated the fact that there will always be scientific uncertainty and that policymakers and those who make regulatory decisions cannot allow themselves to be paralyzed by these gaps in knowledge.

Sure, we can continue to study the problem—and we should continue our studies—but we cannot wait until these studies are completed. We need action.

Those who argue against action like to recite the caveats, uncertainties, and margins of error that accompany scientific reports and projections. But the margins of error usually associated with the greenhouse effect are in terms of mere decades. Disagreements over the accuracy of projections obscure the real issue: Do we have the right to pollute the atmosphere today in a manner that will wreak havoc in as few as 100 to 300 years?

Obviously, no one step is going to solve the multitude of problems associated with these matters. But we must not let the enormity of the task keep us from taking a series of small steps.

Controlling chlorofluorocarbons (CFCs) is a prime example of an important initial step. CFCs are not the only source of the problem, but they are a significant factor; controlling them would represent a major accomplishment. Given the risks associated with ozone modification and climate change, a treaty that immediately limits and ultimately eliminates the availability of harmful CFCs would seem to be a sensible course to pursue. The good news is that, under the leadership of the United Nations Environment Programme, international negotiations to control CFCs are currently under way. The not so good news is that we don't have an agreement yet.

The need for international cooperation in addressing these matters is obvious. We are dealing with a global issue. But the difficulty of getting international agreement should not keep the United States from taking action unilaterally. By taking such action, we can move once again into the role we once proudly held as world leader in environmental protection. We can set the example. A country as large and powerful as ours can afford to make temporary sacrifices that ultimately will benefit all of mankind. The trick will be to do so in a manner that does not unfairly penalize industry in this country.

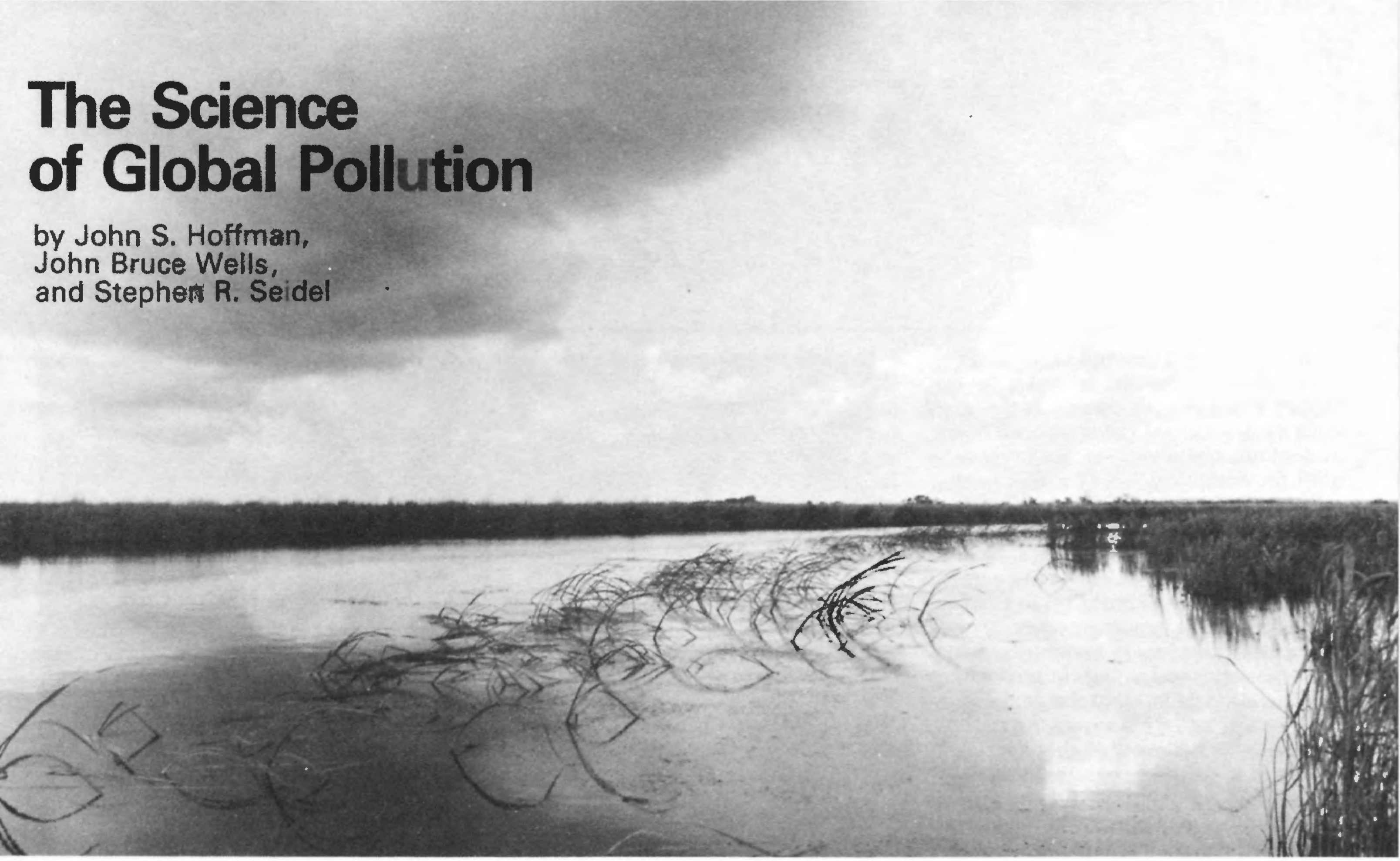
The importance of these issues is matched only by the complexity. But we have faced and solved complex problems before. There is no reason for us to throw up our hands and wait for the inevitable.

We lose so very little by trying. We lose everything by doing nothing.

Tough choices must be made, and we need to start what promises to be a long, sometimes frustrating process. By working together, we can minimize the disruptions that are inevitable. But there will be changes. Future generations—of all life forms—depend on us. □

The Science of Global Pollution

by John S. Hoffman, John Bruce Wells, and Stephen R. Seidel



Steve Delaney

Stratospheric ozone protection and the greenhouse effect represent complex scientific challenges to the global community. The scientific theory behind global warming from the buildup of greenhouse gases dates back well over a century. In 1861, the Irish physicist Tyndall conducted a series of experiments which in effect first demonstrated the greenhouse theory by showing that water vapor absorbs infrared radiation—the heat energy which escapes from earth. Soon after Tyndall's discovery, the Swedish physicist Arrhenius went straight to the heart of the issue by positing that carbon dioxide, another atmospheric gas, would absorb enough infrared radiation to warm the earth by several degrees.

Evidence concerning the existence and role of the ozone layer can be traced to the work of Chapman in the 1930s. About the same time, laboratory scientists for the General Motors corporation developed chlorofluorocarbons (CFCs) for use in refrigeration. The last link in the saga of CFCs and ozone was forged in 1974 when two scientists at the University of California, Rowland and Molina, predicted that CFCs would release chlorine in the upper atmosphere, partially destroying the ozone layer.

Our scientific and industrial progress continues. In a little over a century we have learned that our atmosphere plays an instrumental role in nurturing life on our planet. But we have also learned that as our population and industry have grown in scale, they have become capable of altering the fragile balance of the atmosphere that has evolved over time barely touched by human forces. The carbon cycle, for example, developed slowly over many hundreds of thousands of years. Yet in little over a century following the Industrial Revolution, two concomitant activities—fossil fuel burning and forest clearing—have disrupted this historic cycle and led to a 20 percent increase in atmospheric carbon dioxide levels.

Faced with the knowledge that we now possess the power to fundamentally alter our atmospheric surroundings on a global scale, the world community and its scientists face a new challenge. Can our scientific understanding and resourcefulness keep at least one step ahead of any disruptions that our actions may cause? Can science map for us a future course that allows us to continue down the road of progress while avoiding any inadvertent dangers along the way?

The scientific challenge is to provide information and improve understanding. Because it is scientific evidence that will trigger society's responses to these global environmental issues, scientists must recognize and meet their newfound challenge. Leadership from both industry and elected officials, along with a careful watch by the public, are also essential elements to ensuring that we effectively act upon this scientific knowledge.

(Hoffman is Director of the strategic studies staff in EPA's Office of Policy, Planning, and Evaluation, and manages the stratospheric ozone program in the Agency's Office of Air and Radiation. Wells is President of the Bruce Company, a consulting firm to EPA. Seidel is Senior Analyst in OPPE.)

The Scientific Challenge

Since the age of Francis Bacon in the mid-16th century, science has progressed according to the precepts of observation, experimentation, and repetition. Experiments were carefully designed to test hypotheses, and a

Computer models help scientists study the cycling of carbon through oceans, atmosphere, and biosphere and its possible effects on climate.

Steve Delaney

scientist's findings were not accepted until others had repeated and verified the experiment. Science was not a mental exercise, but one that bloomed in the laboratory. As the laboratory tools became more powerful, the grasp of scientific understanding reached further and further.

The greenhouse effect and ozone depletion represent questions which stretch the scientific process to its limits. Because we have only one earth, we cannot design an experiment which scientists can study, understand, and reproduce. As oceanographer Roger Revelle pointed out in 1957, we "are now carrying out a large-scale geophysical experiment of a kind that could not have happened in the past, nor be repeated in the future".

Development of Models

Laboratory analysis and physical measurements provide important pieces of the complex puzzle that is the greenhouse effect, but many aspects of the overall design remain a mystery. To address this problem, scientists have developed computer models that simulate the millions of interactions that constitute the operation of the natural world. Using models, scientists can study the cycling of carbon through oceans, atmosphere, and biosphere under various conditions. To keep them from being paper exercises, they can also test these models against historical data. For example, the trapped air bubbles in deep ice cores can be studied to reveal the composition of the atmosphere thousands of years ago. The geographic dispersion of fossilized tree pollen can yield clues to the location of forests in the same geologic era, allowing biologists to test whether a climate-biomass model using historical atmospheric conditions would reproduce known forest locations.

Another test involves simulating the conditions of other planets. For example, NASA scientists know the temperatures and atmospheric compositions of Venus and Mars. Given the composition of greenhouse gases in their atmospheres, climate models for these planets can be tested to see if they can reproduce known temperatures. The success of this comparison is one method used to establish the existence of the greenhouse effect and to support the predictive capability of computer models.

Interdisciplinary Approaches

The complexity of these studies demands an interdisciplinary approach. Emissions of trace gases into the atmosphere are not only changing the radiative balance of the earth's surface and affecting its ozone layer; they are also influencing the oceans and biosphere, which in turn will change the composition and climate of the atmosphere. For example, scientists believe that increased carbon dioxide will affect plants in very complex ways. Higher levels of the gas may directly increase photosynthesis and plant growth. Indirectly, climate change related to carbon dioxide and other greenhouse gases might alter precipitation, length of growing season, the life cycle of pests, and competitive balances among plants. Even to begin to understand this interaction between the atmosphere and biosphere requires scientists to cross their often compartmented boundaries. For example, while some researchers are now investigating the influence of climate change on natural vegetation and others are studying the effects of ultraviolet radiation on these same ecosystems, no one has yet attempted to study the *joint* effects of climate change and ultraviolet radiation.

For scientists to investigate successfully the earth's systems for clues to its future, they must continue to develop new research methods and engage in cooperative efforts. We have reached a stage in human society where our capacity to understand the natural world has never been greater, but where our tendency to inadvertently, perhaps irreversibly, alter that world is also unparalleled. We now face a race between our scientific advances and the changes towards which we are propelling the world, and our ability to respond to these advances and changes. It is with optimism about our resourcefulness that we move forward in addressing these issues. □

New Thinking in American Environmentalism

by Frederic D. Krupp

Ten of the country's largest national environmental groups have chosen new leaders in the past two years. As one member of that incoming class, I see not only new faces, but also the beginnings of a new strategy in the movement, one that may make obsolete some of the hard-cast assumptions about environmentalism's role and limits.

The first stage of the movement, represented by President Theodore Roosevelt and the early Sierra Club, was a reaction to truly rapacious exploitation of natural resources in the wake of the Industrial Revolution. The early focus was on conservation, stemming the loss of forest lands and wildlife, especially in the West.

In the 1960s, people began to realize that they, too, were becoming victims of environmental abuse, that the environment at risk was not just the one in Yellowstone Park but also the one we all live in every day. This second stage, often assumed to have begun with Rachel Carson's *Silent Spring*, recognized that the contamination of water, land, and air had sown seeds of destruction for both wildlife and humans.

The strategy in this second phase has been to try to halt abusive pollution, just as the early conservationists tried to end the over-exploitation of resources. Federal laws such as the Clean Air Act and Clean Water Act and agencies like the Environmental Protection Agency reflect this approach.

Second-stage environmentalism has long since earned wide acceptance by the public. By now, it is also stirring some restless comment, not only from those who think it goes too far, but also from those who think it doesn't go far enough. Some believe that environmentalists are relentlessly negative, opposing industry by reflex, standing in the way of growth and driving up costs. Another school of thought, known by the term Deep Ecology (from the book by Bill Devall and George Sessions), worries that today's environmentalists have been co-opted by the political system and have become too willing to compromise, too concerned with reform at the margin instead of root change.

(Krupp is Executive Director of the Environmental Defense Fund. This article originally appeared in the Wall Street Journal.)

But, even as the debate echoes, a third stage of environmental advocacy is emerging, one that is not satisfied with the precast role of opponent to environmental abuses. Its practitioners recognize that, behind the waste dumps and dams and power plants and pesticides that threaten major environmental harm, there are nearly always legitimate social needs—and that long-term solutions lie in finding alternative ways to meet those underlying needs. Otherwise, we are treating only symptoms; the problems will surface again and again. Answer the underlying needs, and you have a lasting cure.

To move beyond reactive opposition demands a high level of economic and scientific expertise. When third-stage environmentalists worry about a proposed dam, for example, they don't only document the damage it will cause. They also search for other ways to address the need for new water or power supplies that the dam is supposed to address. Growth, jobs, taxpayer and stockholder interests, agricultural productivity, adequate water and power for industry and consumers—all these are part of the third-stage agenda.

One of several examples of the third stage in action is the experience of the Environmental Defense Fund (EDF) in California utility regulation. In the late 1970s the country's largest investor-owned utility, Pacific Gas & Electric Co., had plans to build $20 billion in large coal and nuclear power plants. The company thought those plants were indispensable to California's economic health: many others thought they were unbearable impositions on California's environment. An EDF team—a lawyer, an economist, and a computer analyst—developed a package of alternative energy sources and conservation investments, including co-generation, voltage controls, and utility-financed insulation and efficiency improvements.

EDF ultimately persuaded PG&E to adopt the plan. Why? Because it not only met the same electrical needs, but also meant lower prices for consumers and higher returns to PG&E stockholders through a package so innovative it had never been on any utility's drawing board. Today, PG&E is even paying to lease the EDF computer model that showed how. The alternatives made every one of the proposed large power plants unnecessary.

The third stage is a challenge. It demands the environmental movement attract more of the best minds from a wider range of disciplines. Finding new ways to solve persistent problems is harder than merely opposing them. But there are examples of success emerging from various quarters.

The Institute for Local Self-Reliance in Washington, DC, helped Chester, PA, develop a plan for recycling garbage under which the city has now sold $335 million of bonds to build a separation plant. The plant will allow neighboring Philadelphia to save almost one-third of the cost of burning its garbage, while producing less pollution.

Industry itself has demonstrated that such approaches work. Minnesota Mining & Manufacturing Co., showing leadership with its Pollution Prevention Pays program, has saved $328 million by reducing the amount of hazardous and other wastes it creates.

This search for solutions has something to offer both schools of critics described earlier. The criticisms, though toward different ends, both assume that the issue is "either-or": Either the industrial economy wins or the environment wins, with one side's gain being the other's loss. The new environmentalism does not accept "either-or" as inevitable and has shown that in many critical instances it is a fallacy.

This approach can mean new coalitions, even coalitions of former enemies. But the third stage of environmentalism is in no sense a move toward compromise, a search for the in-between position. It will still need skilled advocacy—even in court—against narrow institutional vision or vested interest in the status quo. Nor is it in any way a repudiation of the second-stage approach now crystallized in the major environmental laws (any more than the Clean Air Act is a repudiation of Teddy Roosevelt). Strong regulation of pollution will continue to be necessary, although here, too, increased use of market-oriented incentives holds promise for greater environmental and economic benefits at a lower social and economic cost.

Although EDF can perhaps claim the earliest experience with the new environmentalism, no group can claim to be its cause. The American public does not want conflict between improving our economic well-being and preserving our health and natural resources. The early experience suggests it can have both. ☐

Two "Killer Smogs" the Headlines Missed

by Roy Popkin

Unlike those who died in the choking smogs of London or in the gas clouds in Bhopal or Cameroon, the victims of two of New York City's "killer smogs" went to their deaths unnoticed by local health authorities or the public. Nevertheless, the tragic incidents, in 1953 and 1966, ultimately produced a legacy of cleaner air for the city's millions of residents.

Both of New York's "killer smogs" occurred in late November as Indian summer heat inversions trapped the chemicals and particulates from industrial smokestacks, chimneys, and vehicles that crammed the city streets, keeping the pollutants from rising.

It was years before anyone knew that New Yorkers had died because of the 1953 incident. Ten years after the episode, a Senate Public Works Committee report stated that, "while the air pollution problems of the United States differ from those in Great Britain, similar calamities such as killer smogs have occurred in this country. Until recently, the one usually mentioned was that which struck Donora, PA, in October 1948, where one third of the population of 14,000 became ill and 17 died. This episode was recognized immediately as a disaster. In contrast, an episode that occurred in New York City was not recognized until statistical evidence, presented almost nine years later, disclosed that during a brief period of weather stagnation at the time, in which unusually high levels of sulfur dioxide and smoke shade had been recorded, the number of deaths in New York City had been approximately 200 in excess of normal."

Although New York City's original smoke abatement laws were enacted in the first decade of the century, New Yorkers had grown accustomed to smoke and grit and soot from power plants, factories, incinerators, ships in the harbor, motor vehicles, and apartment house furnaces. The city was just beginning to deal with the problem. Its fledgling air pollution control agency had opened its first laboratory in a dusty high school classroom on 101st Street on October 13, 1953, less than six weeks before the disaster.

(Popkin is a Writer/Editor in the EPA Office of Public Affairs.)

On November 18, laboratory staff observed that concentrations of sulfur dioxide were rising beyond the range considered normal for the city's air. At the same time, a number of New Yorkers were telephoning the lab to complain about eye irritation and coughing. On November 17, the sulfur dioxide level ranged from 0.07 to 0.17 ppm (parts per million). On the 18th, it rose as high as 0.65 ppm; on the 19th to 0.86, not dropping back to "normal" until the 22nd. At the time, SO_2 was the only pollutant measured, but subsequent studies were able to calculate smokeshade values (the degree of haze and murkiness of the air) for the same period with comparable results. A study of concurrent meteorological conditions showed warm, light air trapping cooler, denser air near the ground for several days. This prevented contaminants from rising and dispersing.

It was years before anyone knew that New Yorkers had died because of the 1953 incident.

Most of New York was unaware of what was happening. On November 20th, *New York Daily News* homemaker columnist Sally Joy Brown wrote, "Don't let mild weather fool you. It's time to think Christmas celebrations." The weather forecast was hazy and mild. The first news stories on the smog appeared the following day but did not note the serious dangers involved.

Headlined the *New York Times*: "Smog is Really Smaze! 4-Day Concentration of Smoke and Haze Causes Optical Illusions and Discomfort. Two Airports Close as Fog is Around. Animals at Zoo Restless. Attendance at Empire State Down."

The tabloid *Daily News* said, "Smog Lingers on In Summer Dividend." Wrote a *News* reporter, "The heavy smog and chemical concentration in the air lingered on yesterday in New York, to make the fourth day in a row in which local folks suffered from eye and throat irritations. The unseasonable warmth continued also . . . . .The Health Department yesterday received many calls on how to treat eye irritations."

The newspaper coverage gives no indication of any major health problems, except for an increase in highway and harbor accidents attributed to poor visibility. Any reported increase in hospital admissions seemed to relate to accidents. The study released years later about the actual death toll indicated that checking hospital admissions would not have shown the reason for what amounted to an almost ten percent increase in the city's mortality rate.

New York City Commissioner of Air Pollution Leonard Greenburg was one of the few public officials to take the situation very seriously from a health point of view. On the third day of smog attack the *Times* reported, "Air pollution commissioner Leonard Greenburg warned that continued pollution during an extended condition of inversion could contribute to sickness and deaths, as in London last December." However, no one suspected that New Yorkers were suffering aggravated pulmonary, heart, or other serious health conditions, or that they were dying as a result. The city's health commissioner even said there had been no significant increase in deaths during the smoggy spell. Mortality figures were not immediately available, and it would

Downtown Manhattan looks like Cloud City in this surrealistic view of a 1966 smog attack. Readings of sulfur dioxide, carbon monoxide, and haze reached record levels, and 200 deaths were later attributed to the smog.

be a long time before anyone knew what had really happened.

First published notice of the tragic outcome appeared in *Public Health Reports* in January 1962. The authors included former commissioner Greenburg, by then a professor at the Albert Einstein College of Medicine; Dr. Morris Jacobs, former director of the air pollution control laboratories; and M.M. Braverman, former chief chemist in the laboratories and now director. They reconstructed the development of the air pollution situation day by day. Then, following the advice of a British physician who had done comparable studies after England's 1948 and 1952 killer smogs, they applied statistical methods used in mortality and morbidity studies to determine the daily increase in death rate as compared to normal rates for the month of November. These statistics showed a cumulative increased death toll of between 170 and 200. Studies of the causes of death showed an increase in pulmonary and heart ailments related to the smog, especially in the very young and those over 45.

Their report attracted little notice outside of technical publications until it was used by New York newspapers in background stories during the Thanksgiving weekend smog attack in 1966.

Ironically, on November 23, 1966, a *New York Times* story told of Consolidated Edison's hopes to reduce the amount of sulfur dioxide its plants would be putting into New York's atmosphere during the coming decade. The story noted that New York's atmosphere had the highest concentration of SO_2 in the nation, an average of 0.16 ppm, that high levels of 3.5 ppm had been recorded in Manhattan, and that a level of 1.2 ppm for eight hours is considered fatal. According to the article, the big utility hoped to reduce its annual SO_2 output from 340,000 tons in 1966 to 100,000 in 1976.

Thanksgiving Day 1966 was mild, but the skies were murky gray and low-lying dirty clouds obscured the view of mid-Manhattan streets from the top of the Empire State Building. A million people lined Central Park West and Broadway to watch the traditional Macy's parade. A check with Macy's 20 years later showed no mention of the smog in the store's historical records. Nevertheless, the city's air laboratory, which by now had moved to an old courthouse in Harlem, was recording very high SO_2, particulate, and other pollution levels.

"We came close to closing the city down," he recalls.

The tabloid *Daily News*, which normally would have front paged a parade picture, instead headlined: "Smog Reaches Danger Mark." Inside, the big type read, "Smog Threatens A City Emergency." The *New York Times* added, "Smog Here Near to Danger Points. Patients Warned. Air Gets Purer During Day But Pollution Rises Again to a High in Evening. City Officials Concerned. Night Meeting Held to Weigh Steps If Condition Persists. Utilities' Help Asked."

Austin Heller, the city's Commissioner of Air Pollution, said the pollution index had reached a high of 60.6, more than 10 points over the health danger mark, between eight and nine p.m. on Thursday. The index figures represent a formula based on measuring the combined amount of sulfur dioxide, carbon monoxide, and haze or smoke in the air. He said the readings may have been the highest in New York's history, and, in spite of late night declines, the levels were expected to rise dangerously when rush hour traffic began in the morning and businesses began opening up. For the first time in the city's history, air quality measurements showed that carbon monoxide emissions presented the most significant health threat. Surprisingly, neither in this nor the earlier episode did ozone play a significant role.

Heller put the city on an alert basis. The city's coal burning municipal incinerators were shut down, setting off a mad scramble for garbage scows to move Gotham's holiday garbage accumulation out to sea for dumping. The power companies were asked to switch from coal to gas and oil. The Health Commissioner warned people with chronic lung and heart diseases to stay indoors.

The day after Thanksgiving, Deputy Mayor Robert Price issued what was believed to be the first appeal ever made to New York's citizens in connection with a smog problem. He and Heller asked that all apartment houses and commercial users of heating oil reduce the indoor temperatues to 60°, that apartment houses stop using their incinerators, that the use of personal automobiles be limited, and that trucking companies curtail deliveries as much as possible. At the time, Conrad Simon, now Director, Air and Waste Management Division, in the Environmental Protection Agency's Region 2 Office in New York, was a New York University scientist. He acted as liaison between the city administration and the scientists during the emergency. "We came close to closing the city down," he recalls.

Even though some hospitals did report an increase in clinic and emergency room visits by persons suffering from lung and heart ailments, and the *Daily News* headlined a story, "How Gray Death Fells Old And Young," there was still no reported increase in the city's death rate. (Oddly, it was during this incident that the people of New York learned for the first time of the 1953 deaths, and one public official said that, had the smog reached

Donora levels, 11,000 people might have been killed.) Again, it was not until Dr. Greenburg and his colleagues did a morbidity study and published their findings in the *Archives of Environmental Health* a year after the event that another daily death rate increase attributed to the smog was made public. It was comparable to the one 13 years earlier, with a total of about 200 fatalities.

There was a fortunate aspect to both the 1953 and the 1966 incidents. Each occurred on a weekend when traffic was relatively light and businesses and factories were closed, and the Indian summer weather reduced the demand for heat. Had the episodes occurred on a weekday, pollution levels—and also, probably, the death toll—would have been even higher.

Public officials began almost immediately to attack the problem. In December 1966, the city's administrative code section on air pollution was strengthened insofar as pollutant levels were concerned. But the persistent presence of nitrogen oxides from power plants and automobiles and of unburnt hydrocarbons was a continuing concern. The evolution of new federal and state pollution standards, combined with this concern, led to the enactment of the New York City Air Pollution Control Code in 1971. According to the New York City Department of Environmental Protection, it is one of the "strictest and most comprehensive in the nation."

Has it produced the desired results? In 1969, Norman Cousins, chairman of the Mayor's Task Force on Air Pollution in the City of New York, wrote then Mayor John V. Lindsay:

" . . . New York City's air is cleaner and more breathable today than it was in 1966 . . . We can take a reasonable degree of pride in the fact that no major city, either in the United States or abroad, can show a comparable gain in the fight against air pollution.

"Stagnation conditions existed during four days in September 1969. It is important to ask what would have happened on those days if the pollution levels had continued to worsen at the same rate of deterioration that occurred from 1964 to 1966. The answer is that there could have been a substantial number of casualties. The fact that an episode did not occur attests to the capability of the City's programs to protect its air resource."

The 1984 air quality trends published by EPA show New York City within tolerance levels for the six major pollutants regulated under the Clean Air Act. State of New York statistics show that SO_2 emissions have dropped from 786,000 tons to 83,000 in 1975, and another 20 to 30 percent since then. Particulate emissions are down from 193,000 tons in 1966 to 35,000 in 1975; Nitrous oxide is down from 272,000 tons to 207,500. Carbon monoxide levels, however, have remained about the same and it is this pollutant and ozone (formed in the ambient air through the reaction of other pollutants) which remain a problem.

The CO figures may be misleading. Both the city and EPA attribute current problems to hot spots caused by collection of autmobile and truck fumes in building canyons in areas like the midtown garment and printing trades districts. In these congested traffic areas, every effort is made to keep traffic moving even faster than on other streets, and extra policemen on the street deal with double parking and problems like large trucks delaying traffic while they negotiate difficult intersections.

EPA's Simon says that the air in New York City is "much better today." By 1972, he says, the city's air pollution problems in terms of SO2 and particulates had been halved. Current reports, which may make people think the city is not keeping up with other major metropolitan areas are, in Simon's view, misleading because more than half the needed improvements had already been accomplished before the current monitoring began.

The one potentially serious threat today from the six major pollutants in the New York area would come from ozone.

There have been no more killer smogs. In fact, Simon thinks the only way one could happen now is as the result of a single source explosion or extraordinary situation. These improvements are the legacy of concern that emerged after the 1966 Thanksiving Day smog disaster. □

Is Environmental Control an Expense or an Investment?

by Don Bronkema

No social protest movement of the post-war era came of age as swiftly as environmental protection. Once the province of eccentrics, it became almost overnight the cause and commitment of the vast preponderance of the American people. Expenditures for pollution control soared as we tried to restore the bright skies and sparkling waters of pre-industrial times.

This commitment has never faltered. Between 1970 and 1984, we spent an estimated $433 billion in public and private funds to clean up our air and water. These billions have already paid substantial dividends. The major atmospheric contaminants have been dropping steadily—in some cases, dramatically—over the last decade. We have at the very least held our own, and in places even made great headway in cleansing our rivers and lakes of the so-called classical pollutants. We have laid a foundation for detoxifying abandoned waste dumps and for controlling active dump sites.

However, some still believe that pollution control is more of an expense than an investment and that we just can't afford to spend so much in this otherwise commendable effort. They blame environmental management for lowering the standard of living, throwing thousands out of work, raising the cost of products, cutting into productivity, driving some companies out of business, pushing entire industries over the brink, and giving an advantage to ruthless foreign competitors.

But, according to Management Information Services, Inc. (MISI), these arguments are essentially false. In a report published in January 1986, MISI concluded that pollution abatement has not only provided environmental benefits, it has also provided the impetus for a multi-billion dollar industry. If the industry were concentrated in one company, it would rank near the very top of the Fortune 500.

(Bronkema is a Writer/Editor in the EPA Office of Public Affairs.)

Last year, for example, managers invested $8.5 billion in abatement and control equipment. This in turn created $19.3 billion in sales and 167,000 jobs. The MISI report identifies the beneficiaries of these outlays by industry, occupation, and geographic region. It rebuts the notion that environmental programs are nothing but regulations, standards, compliance monitoring, and such-like bureaucratic paper pushing. In fact, some 80 percent of pollution-related spending is attributable to business activity, consumer goods, construction, and research and product development.

The MISI report confirms that some industries and communities have been gravely disrupted by pollution control, especially old-line heavy industry in the rust belt. But control expenditures also provide contracts for certain mature companies that have fallen on hard times due to competition from other materials, poor sales, and foreign competition. They stimulate frontier companies in high-tech sectors that can help restore the balance of payments, and they have opened up broad opportunities for science, engineering, and technical personnel.

Total business investment in pollution control since the early 1970s, MISI estimates, is now over $100 billion, with much more still to come as the international market for control equipment expands.

The MISI report recognizes that generous spending on the environment probably reduces spending for some popular consumer items. But it notes that a clean and enjoyable environment is an essential feature of the modern standard of living and of contemporary expectations. Indeed, some observers insist that it is a precondition for the survival of the human race.

But what about the jobs and companies and industries that go down the drain? What about the towns and cities and states that can't afford to retrofit for environmental controls and get back into the mainstream? Again, MISI has come up with some surprising facts.

Take a state like Ohio, one beset with adversity as heavy industries like steel, industrial machinery, petrochemicals, and utilities have faced changing market demand, recession, technical obsolescence, and stiff competition from abroad. Ohio industry has doubtless been a major polluter, and it has had to pay out a lot of money for federally mandated improvements. But more often than not, says MISI, those very same industries have also been called upon to produce pollution control equipment and services.

In addition, industrial polluters confronted by tough standards not infrequently come up with innovations that not only help themselves, but inadvertently assist others as well. And, whenever new equipment and processes must be introduced in response to the aforementioned economic conditions, industry can wrap pollution controls into the system at lower cost than likely under complex retrofitting. In that case, cleaner air and water are a collateral benefit of investments that would have had to be made anyway.

The results, in any event, are beneficial. Pollution abatement and control created 8,577 new jobs in Ohio in 1985 and generated additional industrial sales of $963 million.

MISI estimates that in 1985 U.S. business spent $4.2 billion on air-pollution control equipment, $3.2 billion on water-pollution control equipment, and $1.1 billion on equipment for disposal of solid waste. Some $10 billion in industry sales, $1.3 billion in corporate profits, and 85,000 jobs were produced by investments in air-pollution abatement. Water-pollution control expenditures resulted in $7.1 billion in sales, $900 million in profits, and 59,000 jobs. Waste disposal created $2.5 billion in sales, $300 million in profits, and 22,500 jobs.

The study analyzes the economic and employment benefits resulting from each type of control investment, with direct and indirect effects on 80 industries and 475 occupations for the nation as a whole and for various states and regions. MISI reports that air-pollution control creates the most sales and profits per dollar of expenditure, while investment in solidwaste disposal technology generates the most jobs.

The MISI findings are by no means unique. The U.S. Department of Commerce Bureau of Economic Analysis has just reported that pollution control investments in 1984, their latest record, amounted to $69 billion—three-quarters of it private money for expenditures ranging from stack-gas scrubbers to catalytic converters for cars. The Bureau estimates that such expenditures had risen from about 1.5 percent of GNP in 1972 to 1.8 percent in 1984.

The conclusion seems inescapable: environmental management is a major positive element in the American economy. It is setting an example that is occurring in other developed countries and that is beginning to occur in developing countries. It is often at the cutting edge of technical innovation. It boosts productivity and will help make possible the preservation of the global ecosystem upon which life and civilization depend. It is one of those realities of the marketplace that is unlikely to go away. ☐

Update

A review of recent major EPA activities and developments in the pollution control program areas

AIR

Emissions Trading Policy

EPA has completed a seven-year effort by issuing new, final guidelines on the use of emissions trading, or the "bubble," to meet pollution reduction requirements under the Clean Air Act. The Agency's final policy continues to authorize use of environmentally sound bubbles in all areas of the country and is expected to be widely used by states and industry to save pollution-control costs while ensuring continued progress toward clean air.

The bubble allows managers of existing plants to treat all stacks and vents as though they are enclosed by a giant bubble and control less where control costs are high, in exchange for extra, compensating emission reductions where control costs are relatively low, so long as equal or better reductions are achieved at the top of that bubble.

Milton Russell, Assistant Administrator for Policy, Planning and Evaluation, said, "the bubble offers needed flexibility, the ability to respond to changing circumstances, and stronger incentives for environmental progress...."

ENFORCEMENT

Lead Standard Violations

The Agency announced that it is seeking over $40 million in penalties from four corporations involved in an illegal leaded gasoline operation.

EPA alleges in separate citations that the four corporations produced lead gasoline at a Carteret, N.J., facility from Nov. 1, 1982, to Dec. 31, 1985, that greatly exceeded Agency standards on the amount of lead allowed in gasoline. Named in the citations are Will Petroleum, Inc., of Houston, TX; Triad Petroleum, Inc., of New York; A. Tarricone, Inc. (ATI), of New York; and E.I. Dupont DeNemours & Co., Inc.

EPA claims that the four parties are responsible for one of the largest single leaded-gasoline blending operations in the United States. According to the Agency, they produced over 800 million gallons of leaded gasoline.

TOXICS

$1.5 Million Penalty

The Agency has issued an administrative civil complaint and assessed a $1.5 million penalty against De'Longhi American, Inc., for importing for domestic sale radiator heaters that contained oil contaminated with low levels of polychlorinated biphenyls (PCBs). De'Longhi also exported the PCB-containing heaters without EPA authorization. Both actions are in violation of the Toxic Substances Control Act.

EPA was first notified in April 1986 by the Canadian government of the presence of PCB-contaminated oil in De'Longhi radiators. After collecting oil samples, EPA found that up to 50 percent of the De'Longhi heaters with the model numbers 5108, 5108T, and 5307 may be contaminated with low concentrations of PCBs.

Only a small number of De'Longhi heaters have leaked, and manufacturers claim that the chance of an oil leak is small since oil in this type of heater is permanently sealed in copper tubing and therefore isolated even when a heater becomes hot.

HAZARDOUS WASTE

Land Disposal Restrictions

EPA has proposed to restrict the land disposal in hazardous waste facilities of 12 classes of hazardous substances, starting in July 1987. The substances include liquid hazardous wastes containing cyanides, metals, polychlorinated biphenyls (PCBs), corrosive wastes, and both liquid and solid hazardous wastes containing halogenated organic compounds (HOCs).

EPA Administrator Lee M. Thomas said, "EPA is proposing to keep out of the land more than 25 billion gallons of some of the most toxic, mobile, and persistent chemicals and metals produced each year." He also stated that "this action will reduce ... threats to the public and the environment posed by the substances."

These substances were specifically targeted for land disposal restrictions by July 1987 in 1984 amendments to the Resource Conservation and Recovery Act. The law sets specific levels above which wastes containing these substances must be treated prior to any land disposal. Last month, the Agency restricted the land disposal without prior treatment of wastes containing dioxins and solvents.

PESTICIDES

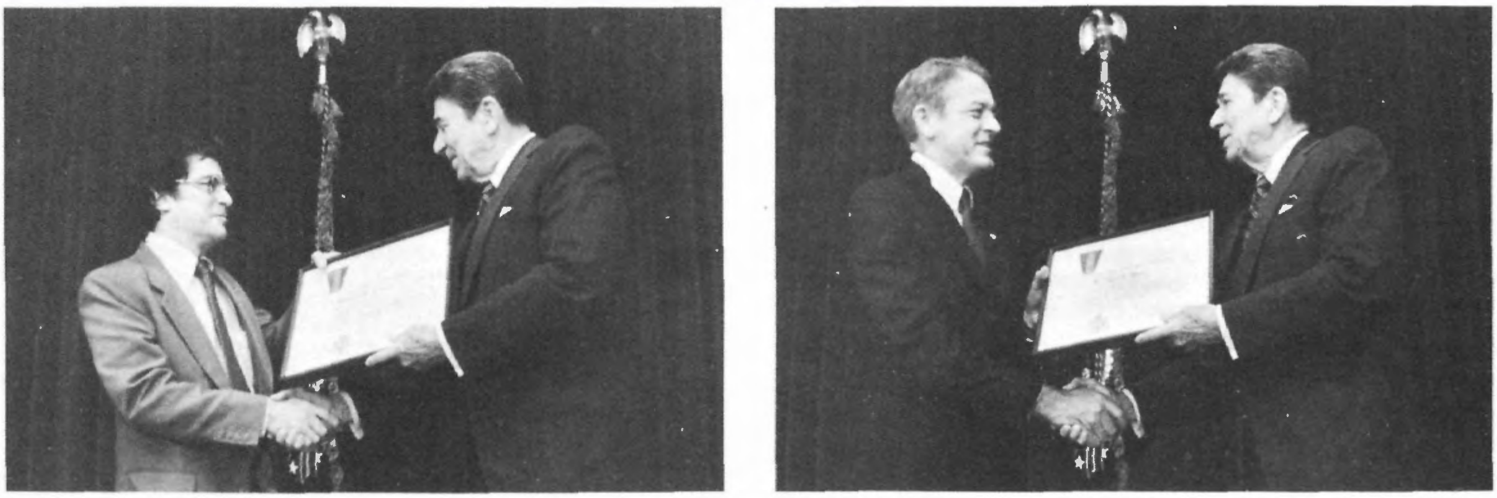
Fees for Registration

EPA is proposing to charge pesticide manufacturers fees ranging from $600 to $163,000 for the registration of their products. These fees will cover some of the costs now incurred by EPA in reviewing and registering pesticides.

Currently, fees for establishing tolerances or permissible pesticide residue levels are the only federal costs incurred by companies that register or license pesticide products.

The $18 million in fees the Agency expects to recover annually under the proposed rule is slightly more than one quarter of all costs EPA expended in fiscal year 1985 to conduct pesticide activities.

Awards and Appointments



President Reagan congratulates Howard Messner (left) and John Moore. The two EPA Assistant Administrators received the Presidential Rank award, Distinguished Executive rank, for extended exceptional service with the Federal government.

Three at EPA Receive Presidential Awards

Every year, a number of career Senior Executive Service (SES) employees are selected to receive the Presidential Rank award for extended exceptional service with the Federal government.

The Agency is proud to announce that among the 1986 recipients of the Presidential Rank award are three EPA employees: Howard M. Messner, Assistant Administrator for Administration and Resource Management, ana John A. Moore, Assistant Administrator for Pesticides and Toxic Substances, both awarded Distinguished Executive rank; and Charles L. Elkins, Director, Office of Toxic Substances, awarded the Meritorious Executive rank.

The Presidential Rank award is highly competitive. In each year, no more than one percent of SES executives may receive Distinguished Executive rank, which carries with it an award of $20,000, and no more than five percent of employees may receive Meritorious Executive rank, which carries an award of $10,000.

Howard Messner's 25-year service with the Federal government has included key management positions with EPA, the Congressional Budget Office, the Office of Management and Budget, and the Department of Energy. Other honors he has received include the William A. Jump Memorial Foundation Award for Exemplary Service in Public Administration and election to the National Academy of Public Administration.

Charles L. Elkins

Dr. John Moore has been with the Federal government for 17 years. Since joining EPA in 1983, he has worked to improve the premanufacture review of new industrial chemicals and the assessment, testing, and regulation of existing chemicals, and to increase public and private sector participation in the regulation and registration of pesticides marketed in the United States. Before coming to EPA, Moore was the key manager in developing technology research and testing in the National Toxicology Program of the Department of Health and Human Services.

Chuck Elkins has been with the Federal government for 20 years and helped establish EPA in 1970. Positions have included Acting Assistant Administrator for Air and Radiation on two occasions, Acting Assistant Administrator for Hazardous Materials Control, Director of the Noise Control Program, and Director of the Acid Rain Policy Staff. Before coming to EPA, Elkins was budget examiner of the Bureau of the Budget for HEW's environmental, occupational, and consumer protection programs.

At press time, EPA Administrator Lee M. Thomas named Robert E. Layton, Jr., to be the new Regional Administrator for Region 6 in Dallas.

A native Texan, Layton resides in Tyler, TX, where he has served on the City Council and as Mayor. He is a graduate of Texas A & M University with a bachelor's degree in aeronautical engineering.

More details will follow in the next *Journal*.

Steve Delaney

Shore birds in Brigantine, NJ. The greenhouse effect will have a major impact on coastal areas *(see story on page 17).*

Back Cover: Skiing at Aspen, CO. Photo by Michael Philip Manheim, Folio, Inc.

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