8 Exceeding the Absorptive Limits of the Global Commons

As soon as several of the inhabitants of the United States have taken up an opinion or feeling which they wish to promote in the world, they look out for mutual assistance; and as soon as they have found each other, they combine. From that moment they are no longer isolated men.
—Alexis de Tocqueville

Threats to the security of our citizens need to be updated and extended to include environmental degradation . . . we are greening our foreign policy.
—U.S. Secretary of State James Baker

The solution of ecological problems is integral to strengthening international peace and security.
—Soviet Foreign Minister Eduard Shevarnadze

Erosion of the Earth's Protective Shield

I was ready for bed when the doorbell rang at our home in the Washington suburbs on a spring evening in 1977. An elegantly dressed middle-aged lady stood on the steps with a thick document in her hand. "We worked around the clock, and it's ready to be sent to the *Federal Register* tomorrow," she beamed with pride. She was the leader of the network of suburban housewives who provided day-and-night secre-

tarial support for the EPA whenever the staff of the Agency had difficulty preparing long and carefully edited documents in response to short deadlines. She was delivering the final draft of the EPA's proposed regulation to ban the use of chlorofluorocarbons (CFCs) in aerosol sprays, a class of chemicals indicted by scientists several years earlier as causing depletion of the ozone layer of the stratosphere.

The EPA staff was particularly proud of this achievement. Beginning in November 1976, in less than six months they had developed and processed through a reluctant bureaucracy a complicated regulation to deal with a significant environmental threat, albeit of unknown dimensions. To arrive at this point the EPA had spearheaded an interagency task force to limit the use of CFCs under a variety of regulatory authorities. In an unprecedented act of interagency coordination, the EPA (pesticide sprays), the Food and Drug Administration (cosmetic sprays), and the Consumer Product Safety Commission (other sprays used around the house) would each propose in the *Federal Register* on the same day regulations to phase out CFCs used in spray cans.

For the record, CFCs have some very desirable properties. They are nonflammable, noncorrosive, nonexplosive, and low in toxicity. They are stable, soluble, and compatible with many types of materials. They had been used for several decades not only as propellants in aerosol sprays, but also as energy-efficient coolants in refrigerators and air conditioners, as gases that provided the expansion properties in energy-efficient foam insulators, and as important ingredients in solvents for cleaning electrical and mechanical equipment.

In 1976, the annual market value of CFCs produced in the United States was more than $700 million, and the value of goods and services directly dependent on these chemicals was in the range of $10 to $20 billion each year. Approximately one-half of the production was used for aerosol sprays. While the United States was the leader in the manufacture of CFCs with almost one-half of the world's production, other countries were rapidly increasing their shares. CFCs have been and still remain a very important commercial product.

In 1974, two American scientists first predicted in the journal *Nature* that the release into the atmosphere of the widely used CFCs would erode the ozone belt which shields the Earth from excessive ultraviolet radiation generated by the sun. Several scientific committees

subsequently confirmed the likelihood of these predictions. Limited measurements of chemical reactions in the upper atmosphere during the mid-1970s began to support the validity of this theory. It seemed likely that on a global basis ozone levels in the stratosphere could decline several percent each decade due to the growing presence of CFCs.[1]

In short, at ground level CFCs are stable and harmless. They generate fine and even sprays, they chill and they insulate, and moreover they are inexpensive to produce. But when they escape into the atmosphere, they slowly rise over a period of several years into the cold stratosphere where they can survive for decades. Then, according to scientists, as they come in contact with water vapor and other chemicals in the low temperature of the stratosphere, particularly in the areas over the north and south poles, they slowly become reactive and sensitive to sunlight. They decompose. The chlorine then attacks the ozone, converting the three molecules of ozone into two molecules of ordinary oxygen.

At the time EPA specialists were preparing the regulation, several government agencies, including the National Science Foundation and the National Aeronautics and Space Administration, were convinced that the theory of ozone depletion was valid although the time scale and the extent of the past erosion of the ozone belt were surrounded by speculation. Medical experts argued that as the ozone levels declined and the intensity of ultraviolet radiation on the Earth's surface rose, the likelihood of skin cancer would increase. But how great would the increase be and what would the increased cancer risk be for any individual? Most of the risk estimates developed by scientists within and outside the government were complicated by reliance on seemingly incomprehensible mathematical equations that simply turned off many policy officials. On the other hand, one understandable estimate of the risk presented by the manufacturers of CFCs was that the effect would be equivalent to moving from the moderate sunshine of Washington, D.C., to the brighter rays of North Carolina.

Agricultural experts were concerned about the possible adverse effect of more intensive ultraviolet light on crops, but they could not provide any estimates of the damage. More worrisome, however, were warnings of some climatologists that a buildup of CFCs could affect the Earth's heat balance and hence alter the global climate. They talked about melting icebergs and changes in the four seasons of the year, but

they could only do so in the vaguest terms. Meanwhile, the American public had become aware of the problem, and boycotts of aerosol propellants had begun in several states.

The EPA was facing a dilemma. How could the Agency persuasively defend a regulation that would at the very outset cost American industry hundreds of millions of dollars, a cost which could be estimated with some certainty, when the regulation provided no assurance of significant environmental benefits? We at the EPA had convinced ourselves that even a remote possibility of climatological change from continued use of CFCs warranted regulatory action, but the range of uncertainty was so broad that the Agency would be hard pressed to rest its case on this argument.

Therefore, the EPA decided to steer away from scientific jargon and justify the regulation in broad terms understandable to the public. First, the Agency would emphasize the "possibility" of increased rates of skin cancer. Washington was being bombarded by constant media exaggeration of the tumor-producing potential of environmental chemicals, and prevention of cancer was a powerful political argument in defending environmental regulations.

Second, the EPA would characterize aerosol sprays as "frivolous" and nonessential, arguing that alternative approaches for applications of cosmetics, pesticides, and other consumer and industrial products were readily available. At that time, Madison Avenue had developed a popular line for TV commercials for deodorants, "Get off the can and get on the stick."

The regulation itself would make only very general references to possible harmful consequences of continued ozone depletion besides cancer. The EPA surely did not want to assume the burden of demonstrating future risks in a dialogue with the affected commercial interests, nor was the EPA prepared to quantify and balance risks and benefits.

This strategy for dealing with aerosol sprays used in the United States worked. Eighteen months later, after some initial industry grumbling, the regulatory agencies enacted final regulations for phasing out sprays using CFCs. However, related efforts to establish a more leisurely but firm timetable for addressing the problems of air conditioners, refrigerators, and foam insulation and to mobilize international

action to control CFCs even in aerosol sprays foundered in the months and years ahead.

On the domestic scene, by the autumn of 1978 when the limitations on aerosols began to take effect, the American public which had become aware of the problem was losing all enthusiasm—which never was very high—for more expensive substitute coolants for refrigerators and air conditioners, feeling that much of the problem had already been resolved. Hairspray is one thing. Frozen food and air conditioning are something else. Second, American industry had managed to maintain its general level of production of CFCs since the markets for coolants and foam insulators were growing. Thus, the key manufacturers were prepared to go along with limitations on aerosols but strongly resisted further limitations on other products. To add to the inertia, while scientific data continued to accumulate confirming the original theory of ozone depletion, the uncertainties surrounding the severity of the problem remained.

Following the issuance of the proposed regulations in 1977 to phase out aerosol sprays, the United States quickly attempted to take the diplomatic lead. During the summer of that year, the Department of State convened in Washington the first intergovernmental meeting on controlling CFCs which attracted most of the west European governments. American scientists had uncovered a problem affecting all people, and the United States had already taken decisive action involving significant economic costs to begin controlling the problem at home. Many other countries were impressed. However, only Canada, the United Kingdom, Norway, and Sweden took prompt action to limit aerosols while other countries, under pressure from their own industrial constituents, dragged their feet.

In the years that followed, the United States did not press these other countries very hard, since arms control, trade, and international financial arrangements were considered far more important than somewhat vague concerns over the ozone belt. Many Europeans argued that in view of the lack of scientific certainty showing the planet was endangered, they were not prepared to constrain their economies. In any event they were preoccupied with regional air pollution problems in Europe. For a decade the international debates and negotiations were held at low levels with little political clout attached to the discussions

among scientists and technicians, and even these discussions became bogged down in haggling among scientists over the uncertainty about atmospheric processes, haggling which the EPA had tried so carefully to avoid at the outset.

Then in 1985 British scientists reported that a hole in the ozone layer over Antarctica had been growing each spring since 1979. The 1984 hole was described as "larger than the United States and taller than Mount Everest." During the next several years, a plethora of scientific reports from American and other scientists using both satellite and ground-based observations issued dire warnings. The hole could continue to spread, and estimates based on the rate the hole was growing suggested the ozone in the Earth's stratosphere would decline by several percent each decade. Scientists argued that this could mean increased cataracts, depressed immune systems, and disruption of sensitive terrestrial and aquatic ecosystems.

Subsequent investigations by other scientists generally confirmed the British findings, and the entire world awoke to the reality of the dangers resulting from an eroding ozone shield. A new sense of urgency led to calls by the Congress and environmental groups for actions in the United States which would limit the use of CFCs as a refrigerant and as a blowing agent in foam insulation. Internationally, by late 1985 the Department of State had elevated the issue of control of CFCs on its list of diplomatic priorities as concerted efforts were initiated by the United States around the globe to reverse the trend in ozone depletion. Initially, American diplomats hesitated to use the "hole" as justification for international action lest subsequent studies rejected the theory, but this hesitation soon disappeared.

In 1986, most of the countries which were the principal manufacturers and consumers of CFCs signed an international convention in Vienna calling in general terms for limitations on CFCs. In the same year, the DuPont Company, the largest manufacturer of CFCs, with one-fourth of the world's production, acknowledged the linkage between CFCs and ozone depletion, and this forthrightness gave considerable impetus to the international effort. Then, after spirited negotiations, in September 1987, 24 countries agreed to an implementing protocol in Montreal calling for a worldwide 50% reduction in CFC emissions by 1998, with initial limitations beginning in 1989. Also, in 1992 the protocol was to freeze emission levels of a class of chemicals

called halons. These chemicals are used in fire extinguishers and contain bromine which is even more destructive to ozone than the chlorine found in CFCs.[2]

At a subsequent meeting in London in 1990, the signatories of the Montreal Protocol agreed to more severe restrictions leading to a ban on the use of CFCs and halons beginning in the year 2000. Two other important ozone-depleting chemicals, carbon tetrachloride and methyl chloroform, are also to be phased out by the years 2000 and 2005, respectively. Of considerable importance, China and India indicated a desire to adhere to the Montreal Protocol. They and other developing countries are to have a ten-year grace period to comply with the agreed timetables. In addition, the industrialized countries pledged to contribute to a fund with an initial three-year budget of $160 million to help the developing countries switch to chemicals and technologies which are less damaging to ozone.[3]

The original Montreal Protocol and the subsequent modifications are frequently hailed as a model for promoting international cooperation in environmental issues of global significance. They certainly have been important first steps in paving the way for stringent limitations on global air pollutants, and they have demonstrated the feasibility of reaching agreement on pollution issues that affect the economic interests of many countries.

Scientists are still not sure of the rate of ozone erosion, but the linkage between the presence of CFCs and ozone destruction is unmistakable. Given the current levels of CFCs already in the stratosphere and the emissions that will be released in the years ahead, ozone depletion will continue during the next decade. Had the U.S. government been more forceful in pressing for limitations on CFC production in the United States and in its international negotiations one decade ago, the accumulation of CFCs in the stratosphere probably would have been significantly less. However, now the United States and other countries must move quickly, even if there is only an outside chance that the most dire predictions of studies by agencies of several governments will come true—predictions that the costs to the world in human health and ecological damage from increased ultraviolet radiation during the next century could run into hundreds of billions of dollars.

One particularly encouraging step was an announcement in 1989 made by the DuPont Company that it would terminate production of

CFCs and would market substitute products with greatly reduced impact on the ozone layer. Hydrofluorocarbons and hydrochlorofluorocarbons appear to be the most promising alternatives. They retain many of the desirable properties of CFCs. At the same time, these newly developed compounds either contain no chlorine or decompose before they reach the stratosphere, and their ozone-depletion potential is less than 10% of the potential of CFCs. Still, the revised Montreal Protocol calls for cessation of their use in 50 years, and in the decades ahead we should keep this warning in mind. Unfortunately, early industrial estimates are that these substitutes are less efficient as coolants and may cost as much as five times more than CFCs. However, prices will undoubtedly decline as competitor companies also develop alternative products for the lucrative refrigerant market.[4]

In the meantime, large quantities of CFCs currently found in refrigerators in almost every American home and in air conditioning units in many homes and in three-fourths of our cars will surely escape into the atmosphere. The feasibility of draining such refrigeration systems and inserting new coolants or of containing CFCs when the refrigerators and automobiles are discarded must be explored. However, the outlook for finding efficient ways to capture these chemicals is not bright.

The case of CFCs is a dramatic example of the global reach of man-made chemicals. While useful and benign in our hands on Earth, these chemicals can indirectly affect our lives in many ways once they waft 10 to 20 miles into the sky. Better understanding of atmospheric interactions and of the effects that increasing levels of ultraviolet radiation can have on Earth is imperative. However, governments have recognized that they can no longer hesitate. They must move forward as rapidly as possible to stringently control these chemicals and to begin to check the erosion of the ozone layer.

At the same time, CFCs are only the tip of the chemical iceberg that is slowly drifting into the globe's gaseous shield. While they are currently the principal culprits of ozone depletion in the stratosphere, the Montreal Protocol includes limitations on other chemicals as well. Still other types of emissions from automative vehicles and from industrial and agricultural facilities have also been identified as contributing to the decline of our ozone shield. For example, methane and carbon

monoxide are participants in the processes leading to changes in ozone levels. In the words of atmospheric scientists, these gases are among "the precursors to the hydrogen, nitrogen, and chlorine oxides which catalyze the destruction of ozone in the stratosphere."[5] Thus, the U.S. government must think broadly about international action to control an array of environmental pollutants if the ozone blanket is to retain its protective power.

Gaseous Pollutants Warm Up the Earth

Let us turn to the related topic of the greenhouse gases. These gases influence how much of the sun's energy is absorbed on Earth and how much is radiated back into space. The popular conception is that these gases act like a giant greenhouse trapping energy emitted from the Earth below them and causing a warming on the surface of the globe. Unlike the resolution of the CFC problem which was highlighted by the international leadership of the United States, our government is perceived as dragging its heels in international negotiations of limitations on the greenhouse gases as other industrialized nations take the lead.

The greenhouse gases include a variety of man-made air pollutants. Carbon dioxide is the most troublesome greenhouse gas, believed to be responsible for over 50% of the greenhouse effect which can be traced to human activities. Other greenhouse gases are the same pollutants that scientists have linked with depletion of the ozone layer, including CFCs (responsible for an estimated one-fourth of man's contribution to the greenhouse effect), methane (responsible for about 15%), and nitrogen oxides (responsible for a smaller but still significant percentage). On a geographic basis, the principal contributors to the greenhouse effect are, according to one estimate, the United States (21%), the USSR (14%), western Europe (14%), China (7%), eastern Europe (6 percent), Brazil (4%), and India (4%).[6]

When present in the atmosphere, the greenhouse gases allow radiation from the sun to penetrate to the Earth's surface since the molecules of these gases do not interfere with energy at short wavelengths characteristic of sunshine. The Earth absorbs the solar energy, converting it to heat in the process, and then radiates some of that energy at longer wavelengths back toward space. However, the greenhouse gases inter-

cept these longer wavelengths and prevent the escape from the Earth's atmosphere of some of the energy. The Earth currently absorbs about two-thirds of the sun's radiation and radiates one-third back toward space. While a buildup of greenhouse gases in the atmosphere will not alter the percentage that escapes into space very much, even small changes in the dispersion of energy can disrupt the delicate energy balance which sustains life as we know it.

Specifically, the trapping of energy close to the Earth can cause a rise in atmospheric temperatures—global warming. Water vapor and other naturally occurring chemicals which have a greenhouse effect analogous to the effect of the man-made chemicals of concern have always retained energy radiated from the Earth in the atmosphere. This natural trapping has been essential to maintaining the temperatures of the globe above subfreezing levels. However, with the increasing buildup of greenhouse gases due to industrial and agricultural activity, temperatures are now slowly rising to higher levels. The rate at which temperatures are increasing or may increase in the future as the gaseous pollutants accumulate is of course a central question.

As we have seen, increased ultraviolet radiation reaching the Earth after the loss of stratospheric ozone due to CFCs has caused great concern in many corners of the world. In recent years, predictions of the consequences of global warming have sounded an even more ominous chord. With each new measurement of increased levels of carbon dioxide in the atmosphere, anxieties heighten. During the late 1980s, the hot summers and the droughts in the United States and elsewhere led many political leaders to believe that the greenhouse effect was already upon us and that real estate investments would soon shift northward. Some scientists, however, argued that the temperature and moisture excursions of the 1980s were simply fluctuations in the perennial cycles of droughts and floods.

If we look back in time, we can see that the concentrations of carbon dioxide and other greenhouse gases in the Earth's atmosphere have increased steadily during the past 100 years—a period of intensive industrialization in many countries. Still, reviews of temperature records during that time have led to conflicting conclusions by the experts as to whether there have been "significant" temperature changes which correlate with the increasing levels of carbon dioxide in the atmosphere. Nevertheless, according to some scientists, by the middle of the

next century levels of the greenhouse gases could be twice current levels, and temperatures could rise at least several degrees Fahrenheit. To provide a perspective, we should note that the temperatures of the ice age 10,000 years ago were about nine degrees lower than at present.

Most scientists are reasonably certain that they have identified the most important chemical contributors to rising temperatures. However, scientific understanding of the processes that lead to global warming is far from adequate. These chemical reactions are complicated and interrelated. Similarly, projections of the consequences of global warming are fraught with uncertainty.[7]

Specialists have constructed elaborate computer models to simulate the conditions on the Earth. Several models have predicted that as a result of the buildup of carbon dioxide and other gases, the temperature of the planet may increase by at least several degrees. If modest changes in the global temperature of four or five degrees occur over several centuries, societies around the globe might be able to adapt to the new environments without major disruptions. However, if such temperature changes occur over a period of only a few decades, societies could have great difficulty adjusting to the new conditions. According to the models, the level of the seas could rise several feet. Some coastal areas would be flooded—in Florida, Long Island, and Louisiana and in low-lying countries around the world such as Bangladesh, Egypt, and Vietnam. As ocean currents change course, storm patterns shift dramatically. Also, temperature and precipitation changes can disrupt agricultural practices. Based on the 1988 experiences, American agriculture would be particularly hard hit. Also, as an extreme, populations in some areas of the world might be forced to move into regions where unfamiliar diseases can attack those lacking natural immunities.

However, if scientists cannot agree on the extent that air pollution levels have influenced surface temperatures in the past, can they realistically predict such linkages in the future? The uncertainties as to the precise relationship between the buildup of greenhouse gases and temperature changes are enormous. Given the stakes involved, everyone agrees that greatly expanded research efforts to better understand the processes affecting the character of the atmosphere are urgently needed. Indeed, almost every governmental research agency throughout the world now has a "global change" research program.

One of the most authoritative statements of scientific understanding of global warming is the 1990 report of an international panel of governmental experts assembled under the auspices of the United Nations Environment Program and the World Meteorological Organization which concluded that:

> We are certain emissions resulting from human activities are substantially increasing the atmospheric concentrations of greenhouse gases: carbon dioxide, methane, chlorofluorocarbons (CFCs), and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in additional warming of the Earth's surface. The longer that emissions continue at present day rates, the greater reductions would have to be for concentrations to stabilize at a given level. The long-lived gases would require immediate reductions in emissions from human activities of over 60 percent to stabilize their concentrations at today's levels.
>
> Based on current model results, we predict under the Business-as-Usual (i.e., no change in current practices) emissions of greenhouse gases, a rate of increase of global mean temperature during the next century of about 0.3 degrees centigrade (or 0.5 degrees Fahrenheit) per decade with an uncertainty range from 0.2 to 0.5 degrees centigrade (or 0.3 to 0.9 degrees Fahrenheit) per decade, greater than we have seen over the past 10,000 years; under the same scenario, we also predict an average rate of global mean sea level rise of about 6 centimeters (or 2.4 inches) per decade over the next century with an uncertainty range of 3 to 10 centimeters (or 1.2 to 3.9 inches) per decade. There are many uncertainties in our predictions particularly with regard to the timing, magnitude, and regional patterns of climate change.

Thus, these experts predict that unless the emissions of greenhouse gases are significantly reduced, within 50 years the Earth's average temperature will increase by 2.7 degrees Fahrenheit, although it could increase by as much as 4.5 degrees; and the level of the seas will rise by about one foot, but they could rise by as much as 1.6 feet. The experts also concluded that:

> Rapid changes in climate will change the composition of ecosystems; some species will benefit while others will be unable to migrate or adapt fast enough and may become extinct . . . . In many cases, the impacts will be felt most severely in regions already under stress, mainly developing countries. The most vulnerable human settlements are those especially exposed to natural hazards, e.g., coastal

> or river flooding, severe drought, landslides, severe storms, and tropical cyclones.[8]

In addition to studies of the problem, what should be done now to *control* the greenhouse gases? Can nations simply delay corrective actions to reduce emissions of the greenhouse gases while waiting for conclusive scientific evidence as to the magnitude and urgency of the problem—evidence that may never be adequately developed or developed too late to alter irreversible trends?

During the initial years of the Bush Administration, tempers flared as U.S. government officials debated the alternatives. The White House staff repeatedly rejected proposals of the EPA and the Congress for the United States to join with other nations of the world in establishing a quantitative worldwide goal for reducing emissions of carbon dioxide. They were concerned over the economic costs to U.S. industry and to consumers from compliance with such a commitment. Initially, the United States, together with the USSR and Japan, became isolated from the other countries by refusing to make the political commitment to such aggressive regulatory action for attacking the greenhouse problem. While these three countries argued that they would take steps to limit emissions, their refusal to endorse a specific target was widely perceived as a political message that the world's leading polluters would continue to consider economic growth more important than the global ecology. Then in 1990 other industrialized countries, undoubtedly influenced to some degree by the position of the United States, also became less enthusiastic about committing to sharp reductions of carbon dioxide.

It seems clear that global temperatures are rising due to human activity and that if unchecked, the increases will eventually cause global disruptions—perhaps in 50 years, perhaps in 100 years, but sooner or later. A variety of approaches are available to reduce the buildup of carbon dioxide and other greenhouse gases, in addition to the important step of phasing out CFCs. They include reducing leakages from pipelines and other man-made sources of methane, shifting from "dirty" coal to "clean" gas, and adopting a variety of energy conservation measures. There is a growing consensus to follow such approaches which will clearly be helpful, but they may not be adequate for slowing the current accumulation of greenhouse gases.

The Bush Administration supports restraints on air pollution that can be justified on the basis of reducing energy costs or reducing health risks. Such steps can at the same time help abate the greenhouse effect. This is called the "no regrets" policy since its success in terms of environmental improvement is not dependent on the uncertain outcome of scientific deliberations over the extent of global warming. The administration reinforces this policy of going slow with regulatory actions by calling for annual research investments of $1 billion (eventually reaching $3 billion) to improve the scientific base for predictions of the likely impact of pollutants on the long-term climate.

Still, the concept of quantitative reduction targets for emissions of greenhouse gases must be faced squarely by the United States, as well as other nations. The concept will not go away. For example, beginning in 1989, several European governments (e.g., Sweden, Norway, West Germany, England, and Denmark) committed themselves to targeted reductions of carbon dioxide. They recognized that their individual actions would be insufficient, but they hoped to be symbols which would inspire others to act. Will the international community, including the United States, make a serious political commitment to reducing greenhouse gases, a commitment that will be believable to many only if it is couched in terms of meaningful emission reduction targets? Living up to such a commitment may be expensive, and nations must be prepared to slow down economic prosperity, at least as we currently define prosperity, today to ensure the well-being of future generations? In 1992 the United Nations will hold a global conference in Brazil on environmental and development issues, and the United States should be prepared to adopt specific reduction targets as well as endorsing the continuing need for research.

In short, society cannot rely on the chance that the 1990 predictions of a likely rise in global temperatures were exaggerated and that the experts underestimated the absorptive capacity of the planet. The longer the delay of corrective actions, the higher are the costs of these actions. More importantly, some harmful effects during the period of inaction may be irreversible and not correctable. Expenditures now to curb carbon dioxide emissions are an insurance policy we can well afford. A "no regrets" policy is a first step, but a timid step that should be supplemented with an insurance policy of additional actions just in

case some of the dire predictions of impending disasters turn out to be warranted.

Coping with Fossil Fuels

Because carbon dioxide emissions from the combustion of fossil fuels play a central role in the greenhouse debate, policy officials throughout the world have focused their attention on ways to reduce carbon dioxide discharges associated with energy production. Most of the current emissions from fossil fuels are attributable to the United States and other industrialized countries. California alone acknowledges responsibility for discharging 3% of the greenhouse gases worldwide, including large quantities of carbon dioxide from fossil fuel combustion. Unfortunately, prospects have not been bright for reducing carbon dioxide releases during the next 50 years in a world bent on greater economic affluence and driven by energy-intensive technologies. Still the power of financial incentives should not be underestimated. At the time of the high OPEC oil prices in the 1970s, industrial organizations throughout the world adopted many measures to reduce their needs for energy supplies and clearly demonstrated that when motivated, they can reduce wasteful consumption patterns of the past.

Popular magazines and the press throughout the world have been inundated with articles depicting a planet suffocating under a cloud of power plant emissions. As a result of both the findings of scientists and this media blitz, reducing the demand for energy and introducing cleaner technologies for generating energy are now attracting long-deserved political support in the United States and elsewhere. At the federal and state levels, officials are calling for larger budgets and stronger laws to provide the technical and legal basis for eliminating wasteful energy practices. Let us hope this support will not fade as it did in the late 1970s when the OPEC oil prices declined and Americans became overly optimistic that new versions of the Clean Air Act would lead to adequate reductions of emissions of many harmful pollutants.

To most Americans, cutting back the demand for energy means driving smaller cars, erecting buildings which have better insulation,

adjusting heating and cooling practices in homes and other structures, and increasing efficiency in electrical power plants and in industrial facilities. However, despite growing political interest and public awareness of the importance of energy conservation, the gap between actual practice and the opportunities for conserving energy is large. The public has taken many easy steps to reduce energy usage and cut utility bills. Nevertheless, large cars, high ceilings, glass buildings, and bright lights seem more popular than ever. Meanwhile, some American industrialists argue that due to economic considerations many inefficient plants cannot be replaced before the end of their normal lifetimes of 30 or more years and that in the interim they have no choice but to operate facilities which were not designed to minimize energy consumption requirements.

In the immediate future, common sense and a modest amount of political will are all that are needed for the United States to introduce more aggressive policies toward energy conservation. Unfortunately, voluntary actions on the part of the American public and our industry in response to general policy pronouncements to save energy have not been adequate in the past. A combination of regulatory and economic incentives will undoubtedly be required. Increased taxes on energy supplies, expanded governmental support for research on energy-saving technologies, and regulatory pressures to reduce fuel consumption of automobiles and trucks are steps that the government can take to encourage much improved energy performance of the nation's fleet of motor vehicles and more effective conservation practices of homeowners and businesses.

As discussed earlier, the government must enforce more stringent requirements for controlling discharges of air pollutants from industrial facilities. This will limit human exposures to harmful chemicals at ground level as well as help mitigate the greenhouse effect. These requirements should, in addition, encourage greater attention to reducing energy wastage when designing and operating industrial facilities.

With regard to cleaner energy technologies, the wind and solar energy euphoria of the 1970s has given way to the harsh economic realities of the 1980s. These technologies simply are not likely to become major contributors to energy generation in the foreseeable future. Still, the Washington-based Worldwatch Institute continues to predict that "direct conversion of solar energy will be the cornerstone

of a sustainable world energy system."[9] If such an approach could become technically and economically feasible, everyone would surely applaud. No other source can rival the sun as a clean and inexhaustible supply of energy. But few experts share the institute's optimism over the likelihood that photovoltaic cells, solar reflectors, and wind farms will be the anchors of electrical grids that support the megacities of the next century. There are simply enormous technical problems in collecting sunlight from broad areas, concentrating it, and distributing it to consumers in large quantities.

Looking ahead 20 years, the energy mix in the United States is most likely to be of the following character: petroleum, 41%; gas, 20%; coal, 25%; nuclear, 6%; hydro, 3%; and solar, biomass, and other renewables, 5%.[10]

In short, a variety of political, economic, and technical measures must be taken to promote energy conservation and to discourage the use of dirty energy technologies during the 1990s. In the longer run, the United States should seek more dramatic changes in its approaches to the generation and use of energy. Unfortunately, one important alternative to fossil fuels, more nuclear power stations, remains in limbo in the wake of the accidents at Three Mile Island and Chernobyl.

Reviving the Nuclear Option

Nuclear power stations offer an attractive alternative for clean energy, devoid of greenhouse gases. However, debates over the lifetime expenses of constructing, operating, and dismantling nuclear facilities, as well as sharply differing views on nuclear safety, divide the advocates who claim large savings from use of nuclear power from opponents who are convinced that the technology is dangerous and the costs are out of control. But as clearly demonstrated in France where nuclear reactors provide two-thirds of the nation's electricity, the technology long ago advanced to the point where the costs and safety are sufficiently competitive with fossil fuel plants to warrant serious consideration of greater reliance on nuclear power.

As discussed before, the technical problems associated with nuclear wastes are manageable if our nation adopts a strategy for the next century of storing contaminated nuclear fuel rods in lead casings on the

Nevada desert rather than now pressing for their permanent disposal in deep geological caverns. However, the populace in many countries remains skeptical over safe operation of nuclear plants. Several personal experiences reflect the basis for this skepticism.

In 1958 while serving at the American Embassy in Belgrade, Yugoslavia, I helped mobilize medical assistance to the victims of an accident at a nuclear research reactor at the edge of the city. The nuclear engineers had decided to operate the reactor even though the automatic control system was being repaired. They failed to properly handle the manual control system, and several deaths ensued when excessive radiation was released despite the valiant efforts of French doctors to save the victims through bone marrow transplants in Paris.

Then, in 1961, while working in the nuclear engineering division of Argonne National Laboratory near Chicago, I took a trip to see firsthand the remnants of an explosion in a nuclear reactor built by the U.S. Army in a remote area of Idaho. The press had reported some of the design and operational flaws leading up to this tragedy which killed several workers. Rumors circulated that one of the reactor operators deliberately caused the accident in a jealous rage over an affair between his wife and another operator. Meanwhile, the national security blanket which was placed over both the reactor and the accident raised many suspicions that safety had not been given a high priority.

At the EPA in 1981 I became immersed in the aftermath of the accident at Three Mile Island. Several reviews of the events highlighted the unlikely scenario of technical mishaps that triggered the reactor's failure. Mechanical devices simply did not work properly, and the reactor's operating crew was not prepared to cope with unexpected technical failures. While there were no physiological effects on the nearby population from the accident, the psychological impacts were serious and linger to this day.

Finally, during several trips to the USSR in the late 1980s, I observed how an aroused public, irritated by the cavalier operating procedures which led to the explosion in the Chernobyl reactor, was trying to dismantle the Soviet nuclear industry. At Chernobyl, more than 30 workers and rescue personnel died, tens of thousands of inhabitants of the region were exposed to radiation levels which will probably increase the incidence of cancer and other diseases among this popula-

tion, and efforts to clean up large contaminated areas many miles from the site will continue for decades.

This track record is attributable in large measure to human failures but even more fundamentally to flawed designs of technological systems which did not give adequate weight to the possibility of such failures. These and other accidents understandably raise many apprehensions around the world about the desirability of continuing, let alone expanding, reliance on nuclear power. Indeed, in recent years many plans for nuclear power plants have been scrapped at home and abroad. Only a few new plants are now coming on-line in Korea, France, and Czechoslovakia, for example.

However, abandoning the nuclear energy option at a time of growing concerns over the greenhouse gases let alone uncertainty over the reliability of petroleum supplies from an unstable Middle East makes little sense. Few advocate closing chemical plants because of the Bhopal tragedy and many other industrial accidents, ceasing ocean shipments of petroleum products because supertankers occasionally run aground, or outlawing explosives which are sometimes misused. The stakes to society in the future of nuclear power are of a similar magnitude of importance. Improved safety features rather than efforts to dismantle the industry should be the order of the day. Such safety must emphasize an extraordinary degree of attention to the training of nuclear operators given the sensitivity of current nuclear systems to human failure.

Nuclear materials can be very hazardous and require special precautions. In addition, the crossovers between military and civilian nuclear activities have long called for measures to prevent diversion of nuclear materials from civilian to military applications, particularly in countries with terrorist tendencies. Also, the lengthy periods that many potent radionuclides survive in the environment underscore the great care that is needed in following these materials to their ultimate disposal site.

During the 1980s the safety procedures within the United States for designing and operating nuclear power stations were overhauled. Minor discrepancies in accepted engineering practices which might have been ignored in the past are now considered major violations of operating procedures. The qualifications and training of reactor operators have been greatly strengthened.

In mid-1989, I observed one of the hundreds of training responses to simulated reactor failures staged each year at the Millstone Nuclear Reactor Complex in Connecticut, as well as at other nuclear plants. These tests provided impressive evidence of the soundness of today's approaches for honing the skills of operators that the U.S. government has adopted. In short, American industry has come a long way in learning how to construct, maintain, and operate nuclear plants safely. The United States needs to diffuse this experience widely to those countries which rely on nuclear power but still have weak safety programs.

Meanwhile, the feasibility of building nuclear power plants which are technologically immune from human failures that could lead to catastrophies seems near at hand. A new generation of "inherently safe" reactors is dominating the drawing boards at many engineering installations in the United States and abroad. The design concepts are based on a simple principle: when a reactor begins to heat up unexpectedly, it shuts down independently of any actions taken by the operator. Moreover, the costs of this refinement of nuclear power reactors are projected to be competitive with fossil fuel costs. Our government should encourage the rapid development and testing of such inherently safe systems.

Of course the sociological impediments to a new generation of nuclear reactors will be severe, even if the environmental advantages seem clear. However, the increasing reality of greenhouse warming is beginning to modify some of the public's negative attitudes toward nuclear power. For example, the National Audubon Society now apparently supports the idea of seriously exploring inherently safe reactors. Other important public interest groups are also beginning to recognize the advantages as well as the liabilities of nuclear power. Assuming that these new systems live up to their advanced billings, a reasonable target would be to double the power generation capacity of nuclear stations throughout the world by the year 2020.

At the same time, governments should not become so enamored of these new approaches that they lose sight of the potential problems with the several hundred reactors on-line in many countries that do not incorporate such "fail-safe" design features. Some of these early reactors will remain in operation for several decades, and attentiveness to their operations is imperative. Unfortunately, the technical skills and

legal requirements for operating a nuclear industry in some countries are not as well developed as in the United States. Therefore, additional reactor accidents around the world seem inevitable during the 1990s. Hopefully, they will be contained with minimal environmental leakages. Another "Chernobyl" could indeed be the political death knoll for nuclear power regardless of the alternative threats posed by the greenhouse gases.

The current policies of the U.S. government toward the continued development of nuclear power as an important energy source during the next century are sound. Strong support for the development of the next generation of reactors together with stringent requirements on the operation of existing reactors makes considerable sense. At the same time, efforts should be expanded to reduce the costs of solar power and to search for other potential breakthrough technologies.

Too Many People around the World

The energy consumption trends in developing countries are taking on increasing significance. With unchecked birthrates in many countries, the global population is already approaching six billion people, and another billion will be added during the next decade. As some of the poor but heavily populated countries slowly industrialize, the energy demand per person increases as well. In particular, China has large coal reserves. All indications show that coal consumption in that country will double by the end of the century as the population continues to grow despite stringent attempts of the Chinese government to limit the size of families to one child. Similarly in India, consumption of coal is increasing and will likely triple in the next twenty years. Many other developing countries, while less well endowed with fossil fuels, are no less determined to provide electricity for the countryside and are seeking energy supplies for this effort. The implications for global warming are obvious.

Most American energy specialists are convinced that population growth and its attendant energy demands must be curbed in the Third World. However, the U.S. government is hobbled in its programs for developing countries by controversies in the United States over the extent of our commitment to foreign aid in general and family planning

in particular and over the most effective and appropriate approaches to interacting with developing countries.

Americans have great difficulty recognizing that their self-interests are increasingly entwined with the fate of billions of people in the Third World. Frequent public opinion polls reveal that many Americans ask, "Why should we help the poor in other countries when we can't take care of the homeless in the United States?" Even our political leaders do not appreciate the extent that money spent abroad now can reap benefits at home in the future, for they repeatedly place unrealistic budget constraints on foreign aid activities. As far as the style of U.S. relations with the poorer countries is concerned, our governmental agencies need to realize that the leaders of these developing countries are determined to shape their own futures. True *partnership* must replace American *patronage* as the key to effective American programs in Asia, Africa, and Latin America.

Even with realigned and strengthened policies and programs toward the Third World, the United States would be able to assume a credible leadership role in seeking reductions of greenhouse gases only when the dividends from more aggressive pollution reduction policies at home become apparent. As long as the United States continues to lead the world in discharges of greenhouse gases with no downturn in current trends, American diplomats will have great difficulty persuading Brazil and other countries to slow population growth and to stop ravaging the tropical forests which absorb carbon dioxide.

Thus, the United States should set an example in energy conservation and pollution control for others to follow. We must also share American scientific and technical skills with the poor countries to provide needed tools for reversing the continued growth of populations and to strengthen worldwide capabilities for conserving forests and other renewable resources of the tropics.

Until the late 1970s the American foreign aid program was a pacesetter in the field of family planning in the Third World. American representatives spoke out repeatedly and eloquently on the advantages of constrained population growth. Then family planning programs became ensnarled in our domestic politics over the propriety of different approaches—particularly abortions.

The complexities of economic development and population growth in undeveloped countries demand attention from the best pool

of scientific talent that the industrialized countries can offer. The motivations underlying the continued rearing of large families in poor countries are manyfold and will be difficult to change. Yet there is no alternative to change. The United States need not become involved in controversial abortion programs which are not supported by the American people. Reducing infant mortality, for example, is an objective everyone can endorse, and we have much to offer developing countries in this area. In the long run, improving the chances of children outliving their parents and thereby being available to care for the elderly may reduce the pressures on parents for many sons and daughters to ensure the survivability of one caring offspring. Also, programs to enhance the education and status of women in the poor countries can over time become important deterrents to excessively large families.

Given the enormity and possible effects of population growth, the United States should greatly increase its financial and technical commitment to help developing countries achieve a balance of population growth and economic and environmental sustainability. The United States should no longer be at the bottom of the list of industrialized countries which contribute to foreign economic assistance (measured in terms of percentage of GNP devoted to foreign aid). Americans have much to gain from more rational development of the Third World.

American resources, together with the resources of other industrialized countries and the developing countries themselves, should be focused on specific goals such as halving world population growth by the end of the century. In the absence of such a clear objective supported by many nations, there is little likelihood that the rate of global population growth will slow significantly. While the Bush Administration and the Congress may take solace in knowing that the United States contributes 40% of all international funds directed to population programs, they should recognize that the total funds from all countries are so small that the likely impact on population growth rates during the 1990s will be marginal at best. At the same time, more funds from the United States, say on the order of $500 million per year, together with a together with a more outspoken and aggressive American leadership role in urging all countries to support family planning, could make a significant difference.

In short, global warming is bringing a new dimension to public policy debates in the United States and around the globe. These debates

affect almost every segment of society as we seek environmentally safe technologies. As predictions of global warming gain greater credibility, the interest in energy conservation, nuclear power, and limitations on population growth will continue to increase. All of these approaches deserve special attention in our efforts to curb the erosion of nature.

The Growing Role of Eco-Diplomacy

Depletion of ozone in the stratosphere and greenhouse warming are examples of the indirect reactions man-made chemicals can trigger when they rise to high altitudes. These reactions have profound long-term implications for the ecology of this planet and for human survival.

A third well-known example of an air pollutant with international repercussions is acid rain. Acid rain is traced to sulfur oxides which are emitted by power plants, automobiles, and some industries. Sulfur oxides lead to atmospheric transformations of chemical structures that can result in severe damage to forests, lakes, and buildings, often hundreds of miles from the sources of the emissions. For more than a decade, acid deposition in Canada which is attributable in part to activities in the midwestern United States has been a dominant topic in U.S.–Canadian diplomatic exchanges. In the closely compacted countries of Northern and Central Europe, forest destruction linked to acidification has reached alarming levels with acrimonious statements of one nation regularly accusing others of intolerable industrial practices.

These three problems caused by common air pollutants that know no boundaries increasingly dominate the agendas of important international gatherings. A sample would include the economic summit of several Western heads of state in Paris in 1989; a gathering of some of the world's political leaders convened by Prime Minister Thatcher shortly thereafter; the convocation of scientists and religious leaders called by the Pope the same year; an international environmental extravaganza hosted by Mikhail Gorbachev in Moscow in early 1990; a White House conference on global ecology several months later; and the Western economic summit in Houston in July 1990. At all of these meetings participants pledged ever greater efforts in the common struggle against mankind's own transgressions. The cold war pressures for

military buildups are rapidly giving way to the pressures for ecological accommodation.

Returning to the more immediate effects on humans and ecological resources of toxic chemicals, the international community, and particularly the Western countries, have for many years been concerned with chemical contamination of foods that are shipped across international boundaries. Occasionally, pesticide residues have been a particularly serious problem, and imported agricultural products have been rejected at U.S. ports. Fortunately, for several decades an international scientific forum called "codex alimentarius" has developed guidelines on acceptable trace levels of chemical contaminants in food and on appropriate methods for measuring such contaminants. These guidelines, which are now accepted by most governments, have been very important in ensuring that chemical poisoning has not become a significant impediment to agricultural trade.

As to industrial chemicals, Western nations were alerted to new types of environmental problems during the 1960s when large Japanese populations suffered food poisoning from cadmium, mercury, and PCBs. Though these incidents were localized problems, they foreshadowed problems with the same chemicals in the United States and Europe. Specifically, in Japan food became contaminated from industrial discharges into fishing areas. In Japan and in other countries encountering similar problems, national actions could be taken without the necessity of concerted international efforts. Nevertheless, the similarity of problems in industrialized areas of many countries and the commonality of the remedial actions developed by individual governments were striking. Most countries facing these problems, including the United States, were eager to pool their knowledge so each could learn from the other.

Meanwhile, European countries were banding together to control pollution in the air and rivers which crossed international borders. In the 1960s European environmental concerns focused on very specific geographic regions which were defined by the mobility of the pollutants. The Rhine River and the Ruhr Basin, for example, became identifiable pollution zones. Even though water basins and air sheds cross international boundaries, the responsible parties and the affected parties were easily identified. The immediately concerned governments

worked out solutions, so they thought. Gradually, however, the difficulty of tracing sources and effects in the long-range transport of pollutants in their original or modified forms was recognized. Now regional pollution problems that have subtle impacts on many countries frequently dominate European environmental debates.

Beginning in the 1970s, Japan, the United States, and the European countries enacted laws to control the manufacture and distribution of a few important chemicals which had highly toxic properties. In the United States, this law was the Toxic Substances Control Act. One aspect of these laws requires an exporting nation to inform potential importers of the presence of chemicals in international shipments and of the properties of the chemicals. These national laws also provide authority for rejecting chemical imports for environmental reasons if necessary.

The economic implications of such laws were obvious from the outset since worldwide trade in bulk chemicals exceeded $100 billion in the 1970s and has grown steadily ever since. While statistics have not been available on worldwide trade in items which are the end products of chemical processing industries, in a sense all goods are chemical products, and chemical decomposition and chemical leakages of end products as well as bulk chemicals occasionally occur during shipments. Thus, the scope for regulation of international trade is very broad.

American officials always worry about international actions which could erode U.S. technological leadership that undergirds much of our export strength. In particular, new agreements requiring disclosures by American firms to other nations of proprietary information on the chemical composition and related properties of many substances and products could affect our competitive edge in the chemical field. Also, if laws regulating research and development in the United States or abroad became so stringent as to dampen innovation within the chemical industry, an area where our national and multinational firms excel, the United States could become a big loser on this front.

During the past 15 years the United States has aggressively sought an international consensus on the character of laws and regulations to control the development, manufacture, and distribution of chemicals—a consensus which will not adversely affect American interests. While representing the United States at discussions of such issues at the

Organization for Economic Cooperation and Development in Paris during the early formulation of these laws in the 1970s, my EPA colleagues and I were continuously confronted with the requests of the West European countries for agreement on more restrictions on the development of new chemicals—an area of great U.S. strength. The same countries opposed efforts to review the possible hazards associated with chemicals which were already on the market. These chemicals had found their niches in Europe, and the European governments were not eager to sacrifice them. While representatives of all countries were presumably motivated by environmental concerns, priorities were surely influenced by economic interests. Only now have the European governments finally accepted the concept of phasing out well-established chemicals which are particularly hazardous to health or ecological resources, but serious *actions* in this area are yet to come.

Discussions concerning toxic substances with our European trading partners have concentrated on several areas. Are the tests conducted in the laboratories of one country, say a European country, acceptable to another country, the United States for example, which is determining whether the chemical can be sold in the United States? More specifically, do scientists of both countries agree that the correct tests are being performed and that the testing procedures are of high quality? Second, can delays in imports and exports of chemicals due to new international trade requirements be minimized? Will the customs services throughout the world help ensure that chemicals don't sit indefinitely in warehouses due to the lack of proper documentation or trained personnel for facilitating their movement? Finally, will differing restrictions in different countries encourage multinational chemical companies to locate their test marketing activities in those countries with the least stringent regulatory requirements? What are the economic and environmental consequences of such practices?[11]

In general, the European nations participating in these discussions in Paris recognize the importance and relative ease in sharing scientific expertise and results of scientific research relevant to the control of toxic chemicals. However, discussions of economic and trade issues are more constrained since proprietary information is frequently at the heart of meaningful dialogues. Thus, scientific rather than economic themes dominate. Science is a critical factor underlying regulatory approaches, and a thorough airing of the less controversial issues of

science and scientific methodologies will continue to be important. At the same time, reaching consensus on the more difficult regulatory issues is also obviously important and needs even greater attention in the future.

In 1992, 12 West European countries with a population exceeding that of the United States will "integrate" their economic policies. Their consolidated approaches to international trade will have numerous repercussions. The United States should expect further efforts among the Europeans themselves for common approaches to regulation of toxic chemicals. Not surprisingly, many American firms are expanding their commercial alliances with West European partners. These alliances will provide the firms with flexibility in locating manufacturing and research facilities in Europe when appropriate. Also, such linkages should ease shipment of chemicals and other products across international boundaries, and more generally put companies in a position to take advantage of those national regulations which are least disruptive to their normal business practices.

Environmental Negotiations at All Levels

The Organization for Economic Cooperation and Development is just one of many international organizations giving high priority to man-made chemicals that find environmental pathways across national boundaries. More than one dozen agencies of the United Nations, another dozen international scientific organizations, and still another dozen well-established international research centers bring together thousands of scientists and policy officials from around the world every year to consider many aspects of chemical pollution. Environmental issues command an increasingly prominent position on the agendas of international business organizations. Some international financial institutions such as the World Bank have made major commitments to linking their industrial loan activities with the environmental sensitivity of loan recipients. Others give increasing weight to the feasibility of environmental problems in determining the credit ratings of governments, with the USSR and Eastern Europe being recent losers in trying to retain high ratings.

Meanwhile, many prominent public figures from Hollywood to

Wall Street have taken up the cause of worldwide environmental protection and derive great pleasure in using their high visibility for the cause. For example, Robert Redford hosts meetings of international leaders in resource conservation and global warming at his highly photogenic retreat in Sundance, Utah. He has surrounded himself with many environmental experts and has made many useful contributions to the international dialogue on environmental issues.

Environmental diplomacy has entered the foreign policy arena in other ways. For decades, environmental protection of the Great Lakes has been a recurrent theme in the diplomatic debates between the United States and Canada. Many successes have been recorded in limiting discharges into the lakes of sewage, detergents, and asbestos, for example. In recent years, great attention has been directed to PCB contamination which still plagues the lakes. To the south, our Department of State remains frustrated in its efforts to limit waste discharges from Mexico which pollute the beaches and streams of southern California. Also, air pollution from Mexican industries along the border are frequently a bone of contention. In Europe, many countries have signed agreements to limit chemical discharges into the Mediterranean and Baltic seas. While these international commitments have undoubtedly tempered some temptations to avoid pollution controls, many beaches remain closed. All of these efforts are commendable, but we need to realize that environment commitments do not always equate to environmental improvement or even to compliance with such commitments.

Bilateral agreements between the United States and many countries to promote cooperation in environmental research have become very fashionable. For example, the East–West political dialogue increasingly includes discussions of ecological issues. The United States and the USSR, for example, now have more than 40 formally negotiated cooperative projects in the environmental field, as well as many more less formal arrangements. As to Eastern European, the recent political reforms were stimulated in part by citizen anger over environmental deterioration, and now unprecedented opportunities exist for international cooperation and assistance in one of the world's most highly polluted areas.

As noted, a summit of environmental leaders from many countries is scheduled in Brazil in 1992 under the auspices of the United Nations.

Much of the current international effort is directed to preparing treaties which can be signed in connection with that meeting. At the top of the list is a treaty to put a quantitative cap on discharges of greenhouse gases. In the interim, several steps have already been taken to cut back air pollutants on an international scale. In particular, agreements have been signed by a number of countries to reduce discharges of sulfur oxides and nitrous oxides. However, gaining wider acceptance of these existing treaty provisions, ensuring that the signatories live up to their commitments, and then achieving a consensus on approaches to reduce carbon dioxide emissions are formidable diplomatic tasks facing the international community.

One popular concept being pressed by some developing nations but resisted by most industrial countries is a worldwide tax on emissions of greenhouse gases from energy sources with the proceeds placed at the disposal of poor countries. Such a tax would be sufficiently high to encourage faster movement toward the use of less polluting energy systems. This approach combines the long-standing demands of the developing countries for redistribution of the world's economic wealth, since the developed countries would pay most of the taxes, with international efforts to conserve energy and reduce discharges of carbon dioxide and other pollutants which contribute to global warming.

However, for the concept of an international emissions tax to have any chance of serious consideration by most of the industrialized nations, imaginative ways for using the revenues in the interests of both the developed and developing countries must be devised. The industrialized countries will not simply put more money in the foreign assistance basket. For example, the revenues might be used to offset a portion of the current national contributions to the World Bank and other UN agencies devoted to supporting economic development in the Third World. Conceptually, those countries which are the heaviest polluters of the global commons would have the heaviest burden of supporting economic development of the human resources that populate the globe. In practical terms, the industrialized nations would have an incentive to reduce emissions. Also, they could be encouraged to increase their overall contributions to international foreign assistance through the tax and other means if they are assured that the developing

countries, as their commitment, take steps to curtail population growth and introduce cleaner technologies themselves.

Another contentious issue which should be resolved by the time of the Brazil meeting is the international transport and disposal of hazardous wastes. In recent years, the toxic waste transfer industry has become a big international business, as the costs of proper disposal of wastes in industrial nations have increased significantly. By offering developing nations, or more frequently officials in these nations, economic incentives to accept the wastes, Western entrepreneurs have been able to send toxic barges to sea which return to their home ports mysteriously empty. This practice of dumping hazardous wastes in the poor countries may seem abhorrent to American environmentalists, but when countries are in desperate need of money and have unused land, development of a waste disposal industry may make sense to them. Of course a paramount need is to ensure that such an industry is managed responsibly without corruption and does not introduce long-term dangers into the country.

During 1988 a spate of stories appeared in the press about barges laden with wastes that no one would accept. During my visit to Bucharest, Romania, at that time, the story broke that several Romanian ministers were summarily dismissed for accepting toxic wastes from abroad which had resulted in enormous disposal problems along the Black Sea coast. Perhaps these ministers assumed that amid the already heavy pollution in the country, additional wastes wouldn't be noticed. But they were wrong. Highly concentrated toxic wastes pose very different types of hazards than the blankets of pollutants that build up from discharges into the air and water from improperly controlled industrial processes. Politically, coping with domestic pollution is far different than accepting someone else's refuse. Even during Romania's days of dictatorial oppression, toxic wastes broke through the veil of secrecy surrounding governmental corruption. Now, several dozen nations, including the United States, have signed a treaty which forbids transport of hazardous wastes to countries where there is reason to believe environmentally sound disposal may not take place. This treaty requires the written agreement by the government of the receiving country to accept and dispose of toxic wastes in an environmentally safe manner before shipments can take place.

Turning to disposal of wastes at sea, the United States currently belongs to the London Dumping Convention which sets forth limitations on disposal of toxic wastes. This agreement does not prohibit ocean disposal of "normal" municipal waste which is dumped in designated locations along the coastlines of the world. One such site 200 miles off the New Jersey coast which services the garbage scows of New York City has been referred to as "the most disgusting place on Earth" because of the heavy concentration of smelly wastes that are carted there.

International Ecological Security

The international ramifications of environmental issues are growing daily. In 1989 Jessica Tuchman Mathews, writing in the American journal *Foreign Affairs,* tied environmental and related trends to the security of our nation as follows:

> The 1990s will demand a redefinition of what constitutes national security. In the 1970s the concept was expanded to include international economics as it became clear that the US economy was no longer the independent force it had once been, but was powerfully affected by economic policies in dozens of other countries. Global developments now suggest the need for another analogous, broadening definition of national security to include resource, environmental, and demographic issues.
>
> The assumptions . . . that have governed international relations in the postwar era are a poor fit with these new realities. Environmental strains . . . are already beginning to break down the sacred boundaries of national sovereignty . . . . The once sharp dividing line between foreign and domestic policy is blurred, forcing governments to grapple in international forums with issues that were contentious enough in the domestic arena.[12]

These views have been echoed by the president, the secretary of state, and other American foreign policy officials during the past several years. In many American research institutions, ecological concerns are rapidly being accepted as a legitimate dimension of national security by academics and by policy analysts. Foreign policy practitioners throughout the U.S. government struggle to realign traditional concepts of national security within the constraints of established policy direc-

tives that have historical roots antedating the current environmental awakening.

For more than 40 years, however, Americans had become accustomed to thinking about national security in terms of military forces—capability to deter a nuclear attack by the Soviets, to repel a land invasion across Central Europe, to quell rebellions in the Third World, and to retaliate against acts of terrorism in the Middle East and elsewhere. National security has traditionally been equated, explicitly and implicitly, with near-term survival by avoiding the ravishes of war—survival of Americans at home and abroad and survival of allies and others who share democratic ideals. A large military–industrial complex is in place, dependent on large defense budgets to ensure their survival through continuous modernization of weaponry and through strengthening logistics capabilities to wage war anywhere—in the sky, on the oceans, and on land.

As highlighted in the *Foreign Affairs* article, this thinking of the past is now giving way to the realities of the future. The crumbling of the Soviet bloc does not mean that the United States is becoming a military ally with the Soviet Union, but it certainly places a different cast on the nature of the nuclear threat and the threat of a Soviet invasion of Western Europe. Our inability to effectively use military forces in Lebanon, Southeast Asia, and Central America has raised great doubts about the viability of national security strategies which pivot around military supremacy even in the Third World.

While the military component of national security obviously remains very important, a challenge of growing magnitude must receive comparable attention—the doubling of the world's population in the next half century and the likelihood of related disruptions of natural systems that sustain human life. During the past 40 years, the percentage of the world's population living in industrialized countries slipped from 40 to 20% and most of the projected population growth will continue in the Third World. As has been the case in the industrialized countries, chemicals will play a central role in shaping the life-styles of these growing populations—in ensuring their food supplies, in providing clothing and consumer goods, and in enabling them to slowly enter the industrial age. How these chemicals are handled will be a pivotal factor in the determination of the future of the planet.

As previously noted, the ability of the United States to influence changes in the world's demography and to mitigate the attendant environmental consequences is highly dependent on domestic policies. The United States is the largest contributor to the most important global ecological problems. At the same time, we are the world's leader in science and technology which can help mitigate the causes of environmental degradation in both the industrialized countries and the Third World. But first we need to have our own house in order if we expect to chart a course for others to follow or even to declare certain courses of development as off-limits.

In summary, the nations of the world are ill prepared to enter the 21st century—the environmental century. The 1990s will undoubtedly be a period of frantic international meetings to improve this state of preparedness. Dozens of international organizations will be vying for leadership roles, and new environmental bodies will be created to raise environmental issues to a higher political level. National leaders from both the rich and poor countries will be pinning their reputations to professed concerns over the global commons. Environmentalists will become statesmen, and statesmen will become environmentalists. Treaties will be drafted, watered down, and eventually signed to limit polluting activities. International foreign aid programs of the World Bank and other UN and regional agencies will be reoriented to promote "sustainable" development—development less reliant on fertilizers and pesticides, development that preserves forested areas, and development that limits the spread of urban areas. However, the critical issue of population growth will remain a controversial topic in Washington and internationally.

Turning to our scientists, they will develop a wide array of new technologies to understand and reduce pollution problems. They will deploy a variety of techniques—from space satellites to underwater research vessels—for measuring the state of the environment. They will continue to search for ways to measure the extent and costs of environmental changes that humans wreak on this planet.

For the United States, a decisive issue will be its approach to national security and to the supporting federal budgets. As noted in an earlier chapter, in the past national security budgets have emphasized support for a triad of nuclear warheads deployed in submarines, bombers, and land-based missiles. America now needs a new national se-

curity triad of military strength, economic prosperity, and ecological preservation. National expenditures should be balanced among each leg of this triad. The current distribution of almost $300 billion of federal funds annually for countering military threats, $75 billion (including $60 billion by the private sector) to address concrete pollution problems, and $6 billion for economic cooperation with countries with three-fourths of the world's population is no longer appropriate.

Finally, the struggles between the ideologies of East and West and the economic disparities between North and South will continue during the next decade. But a new struggle between us (the polluters) and us (the victims of our own pollution) will gain international recognition as a crucial security issue of the next century. The nations of the world need to band together as never before if "we" are to be the victors. The international community spends $14 billion each week for support of military forces worldwide. Fourteen billion dollars each year could support a host of new programs in developing countries to help sustain the natural equilibrium not only of the Third World but on a global scale. Which is more important?

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