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Howard J. Taubenfeld

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HOWARD J. TAUBENFELD

It may have been true a century ago that "everyone talked about the weather, but no one did anything about it." In recent years, however, while humans have been talking ever more about weather and climate, they are also doing something about it. In general, human activities have affected or may affect weather and climate in at least three ways: (1) conscious efforts to change weather and climate; (2) conscious national projects with unintended environmental shifts; and (3) major inadvertent environmental and climatic change. These effects, intended or not, create political issues, some of which are potentially issues of national and human survival. It is far from premature to focus attention on these areas. In many instances, the nature of the problems is already discernible and action is already necessary, for the effects of a failure to act immediately may not be felt for decades, and when these effects are felt, they may have become irreversible.

I. CONSCIOUS EFFORTS TO CHANGE WEATHER AND CLIMATE

Throughout recorded history, and perhaps for as long as humans have been able to formulate the thought, men have sought to change or at least influence the "gods of weather." They have danced, sung, sacrificed, prayed, fired cannons, and exploded dynamite taken aloft by kites. Only since the mid-1940's has science been involved in earnest. Just after the Second World War, Langmuir and Schaefer demonstrated that it was both theoretically and practically possible to affect water in the atmosphere by the introduction into a cloud of tiny particles of matter.[1] Dry ice was used initially; silver iodide has been used in most efforts since. Given a precipitation-pregnant situation in the atmosphere, the introduction of additional nuclei to which water vapor may cling appears to produce more precipitation than would otherwise have occurred. An excess introduction of particles might inhibit the creation of large hailstorms or, indeed, might lessen precipitation if it was so desired.

The efforts of the past thirty-five years to deliberately modify weather appear to have produced modest results. They have, however,

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Howard J. Taubenfeld is a professor of law at Southern Methodist University. A.B., 1947; LL.B., 1948; Ph.D., 1958, Columbia University.

1. Langmuir, Schaefer, and Vonnegut, addresses to the American Physical Society, *reported in* N.Y. Times, Jan. 31, 1947, at 16, col. 1; Schaefer, *Man-made Snow*, 69 MECH. ENG. 32 (1947); Schaefer, *Production of Ice Crystals in a Cloud of Supercooled Water Droplets*, 104 SCIENCE 457 (1946); *see generally* Ball, *Shaping the Law of Weather Control*, 58 YALE L.J. 213 (1949).

created substantial domestic and even international controversy.[2] At present, there is no real evidence that large-scale climatic effects can be intentionally produced. We know that we can remove supercooled fog from airports for limited periods; that individual cumulus clouds can be made to grow and often to produce rain; that orographic clouds (those already rising as they are carried from west to east over the United States' western mountains, for example) can be induced to precipitate more than we would expect in nature.[3] From increasing rain production from other large storm systems to decreasing hail or hail damage, and in modifying hurricanes to reduce their wind speed and hence damage due to wind and storm surge, the evidence is promising but unproven.

What are the risks at the international level from this promising if partially unproven technology? First, there is the possibility that an experiment or operation in one country will cause direct, demonstrable harm in another.[4] It is conceivable, for example, that augmenting the flow of an international river might cause damage to a lower riparian state. Where the cause-effect relationship is clear, there are precedents in the developing law of international rivers to make responsibility clear. The mechanisms for recouping losses are not as well developed.

Second, there is the possibility, demonstrated repeatedly in the United States, that a state or its citizens may feel that weather modification activities in another nation are causing harm to them even though no cause-effect relation can be shown. There is also the human perception that can be summarized as the "rob Peter to pay Paul" principle. There is an ingrained human feeling that an increase of rain in one place must correspondingly decrease it somewhere else. Most scientists feel this is not true, that there is so much water in the air that cloud seeding may increase precipitation outside a target area, or not affect the area at all. Yet even if scientifically demonstrable, many people will find this hard to believe. Disputes of this type have arisen, however, with respect to a perceived harm when in fact no weather modification activities have taken place. Since perceptions are as strong as reality, perhaps in such cases some form of impartial fact-finding will ameliorate the problem.

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2. *See generally* G. BREUER, WEATHER MODIFICATION, PROSPECTS AND PROBLEMS (1980); Danielson, Sherk, & Grant, *Legal System Requirements to Control and Facilitate Water Augmentation in the Western United States*, 6 DEN. J. INT'L L. & POL'Y 511 (1976); Samuels, *Prospective International Control of Weather Modification Activities*, 21 U. TORONTO L.J. 222 (1971); Sigel, *International Control of Weather Modification in a Regime of Long-Range Weather Forecasting*, 19 HARV. INT'L L.J. 535 (1978); Wood, *The Status of Weather Modification Activities Under United States and International Law*, 10 NAT. RESOURCES LAW. 367 (1977-78); Note, *Weather Genesis and Weather Neutralization: A New Approach to Weather Modification*, 6 CALIF. W. INT'L L.J. 412 (1976).

3. Samuels, *International Control of Weather Modification Activities: Peril or Policy?*, 13 NAT. RESOURCES J. 327 n.1 (1973); Taubenfeld, *International Environmental Law: Air and Outer Space*, 13 NAT. RESOURCES J. 315, 321 (1973).

4. LEGAL AND SCIENTIFIC UNCERTAINTIES OF WEATHER MODIFICATION (W. Thomas ed. 1977). *See generally* Hassett, *Weather Modification and Control: International Organizational Prospects*, 7 TEX. INT'L L.J. 89 (1971-72); Samuels, note 3 *supra*.

Third, there is the problem of risk-sharing between nations. Hurricanes (called typhoons in the Pacific) produce wind damage, storm surge damage, and flooding rainstorms. Many nations, however, depend on these storms for much of their needed rainfall. If it becomes possible to diminish the wind but spread the storm, or to dissipate much of the storm, who would make the decision? If, to avoid great damage to Texas, we could turn a hurricane toward Cuba, is this a permissible act of self-defense against a devastating natural phenomenon? While much of this is fanciful at present, it is important to consider the appropriate international approaches to channeling these capabilities for weather modification into internationally acceptable patterns.[5]

One further issue cannot be avoided although the threat may have been laid to rest for the present. Weather has always been of importance in military operations.[6] As a Navy scientist stated to the Congress many years ago: "We regard the weather as a weapon. Anything one can use to get his way is a weapon and the weather is as good a one as any."[7] The modest efforts of American forces to enhance rainfall to interdict enemy forces in some stages of the war in Vietnam do not seem to have produced any long-lasting physical effects. The general feeling that it is somehow wrong to tamper with "Mother Nature," however, combined with more realistic fears of the potentially untoward and unpredictable effects of attempting large-scale climatic shifts have led to a treaty, accepted by the world's major powers, renouncing the use of such environmental modification as a weapon.[8] It is unclear whether humans could do these things to each other and to the environment. It is well that they have agreed not to try.

II. CONSCIOUS NATIONAL PROJECTS WITH UNINTENDED ENVIRONMENTAL SHIFTS

Of potentially far greater importance to a politically stable world than intentional weather modification are those human activities which have or may have inadvertent impacts on weather and climate.[9] Two ma-

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5. Taubenfeld, *Weather Modification and Control: Some International Legal Implications*, 55 CALIF. L. REV. 493 (1967). *See also* Hassett, note 4 *supra;* Samuels, note 2 *supra;* Wood, note 2 *supra.*

6. Examples would include the storm that helped save England from the Spanish Armada and the determination of D-Day for Europe in 1944 by the weather outlook. The possibility of using weather to deny information to an enemy, to create battlefield hazards, and to destroy crops have all been considered.

7. 13 NAT. RESOURCES J. 315, 323 n.23 (1973).

8. Convention on the Prohibition of Military or any Other Hostile Use of Environmental Modification Techniques, *done at* Geneva, May 18, 1977, *entered into force* for the United States, Jan. 17, 1980, T.I.A.S. No. 9614.

9. A review of the impacts of a number of human activities on the atmosphere can be found in INADVERTENT CLIMATE MODIFICATION: REPORT OF THE STUDY OF MAN'S IMPACT ON CLIMATE (SMIC) (1971) [hereinafter referred to as INADVERTENT CLIMATE MODIFICATION]. *See also* Coppoc, *The Environment: No Respecter of National Boundaries*, 43 ALB. L. REV. 520 (1979); Dickstein, *National Environmental Hazards and International Law*, 23 INT'L &

jor examples may be cited.

First, scientists and engineers in the Soviet Union have from time to time announced major engineering plans to reverse the flow of major Siberian rivers.[10] River flows can be altered. In the United States, the flow of the river at Chicago was reversed in this century. Russia has already reportedly shifted the flow of a river in Central Russia. Plans to shift the flow of the Jordan River some decades ago were denounced by both Israel and Jordan as a *causus belli* if the other did it.[11]

The Soviet plans for Siberian rivers are not, however, "hostile." They are designed to serve several national purposes. The changes would provide increased flows of water for irrigation over wide areas and would help replenish the waters in Russia's inland seas. Moreover, since fresh water freezes more rapidly than salt water, the diminished flow of fresh water into the Arctic Sea from the rivers which would now, in major part, flow south rather than north, would serve to help keep Russian Arctic ports ice-free for somewhat longer periods. Irrigation, more reserve water, and ice-free ports are all important for domestic purposes. Why is there a potential problem?

In analyzing this situation, scientists have pointed out that an irreversible chain reaction may be started. As the areas around the river mouths remain ice-free longer, more "black" water is available to absorb solar heat. Ice, in contrast, reflects more heat upward. As more heat is absorbed by the water, more ice will melt. As more ice melts, more open water is available to absorb heat until, at some point, the relatively thin ice cover on the Arctic Sea may disappear completely. We know that the Arctic has been ice-free many times in geological history. We do not know, however, what the short or long-term effects would be on regional and world climate if the Arctic ice disappeared rather precipitously in the next decades.[12]

Second, we are now witnessing a rather remarkable assault on many of the world's major forests. Brazil and other countries are making major inroads on the great forests which cover substantial portions of their territory. Brazil, for example, has been engaged in a large-scale effort to replace its forests with farm land. The dramatic increases in the price of wood and forest products in recent decades have further accelerated demand for the removal of the trees.

Again, it is reasonable to ask why a country's domestic policies can be suggested as an important area of international concern and scrutiny

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COMP. L.Q. 426 (1974); Jackson, *The Dimensions of International Pollution*, 50 OR. L. REV. 223 (1970-71); Joyner & Joyner, *Global Eco-Management and International Organization: The Stockholm Conference and Problems of Cooperation*, 14 NAT. RESOURCES J. 533 (1974); Muir, *Legal and Ecological Aspects of the International Energy Situation*, 8 INT'L LAW. 1 (1974).

10. Taubenfeld, *supra* note 3, at 322; Wood, *supra* note 2, at 385 n.67.

11. Taubenfeld, *supra* note 5, at 501 n.43.

12. *See* Taubenfeld, note 3 *supra*.

and, again, the answer is the same. The forests, as tremendous green areas (especially those in the equatorial belt), are the "source" of much of the world's climate. A dramatic change in these forests is certain to produce changes elsewhere, but no one is sure what these changes will be.

Furthermore, as will be discussed in more detail later, the world is already facing a number of potential problems due to the vast increase of carbon dioxide (CO_2) resulting from human activities. One major natural "sink" for carbon dioxide is the green areas of the globe. As forests are eliminated, the cutting and clearing apparently releases CO_2, as does the burning of wood, and the replacement of a forest with an open or an urban area means that there is less green surface available to absorb CO_2. These "domestic" practices and policies may have extremely widespread, if completely unintended, effects.[13] At present, the international legal system has but the most embryonic techniques for dealing with such national activities. Even raising the question may be considered an unwarranted interference with domestic concerns. Still, the awesome possibilities of unwanted and irreversible change do exist.

III. MAJOR INADVERTENT ENVIRONMENTAL AND CLIMATIC CHANGE

In a broad sense, every human activity affects the climate, at least on a tiny microscale. When humans replace farm or pasture land, or a forest, with a city, the local weather changes. A city is a "heat island." Air is warmed and rises as it moves over the city. Industry, specifically the burning of fossil fuels, places large numbers of particles in the air. This unintentional cloud seeding has an effect similar to that sought by intentional weather modification. Extensive studies in and around St. Louis and its "downwind" areas, for example, show that, as contrasted with some decades ago, the downwind areas are subjected annually to a substantially greater number of serious storms and to an increased amount of hail.[14]

In a different way, some scientists have suggested that desertification is, in part and in some areas, due to patterns of animal husbandry. Cattle will eat growing greens but leave a stubble; sheep will eat to the earth; goats will dig the roots as well. Where goats graze on the margins of a desert, they permanently destroy the grass and the desert widens. As the desert widens, some argue, more dust and nuclei are released to the heavens. The result is that clouds are overseeded, rain does not fall and desertification is reinforced.

With the spread of industrialization, the increased demand for electric power, and the creation of new products, the use of the atmosphere

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13. *Id.*

14. *See, e.g.*, Gatz, *An Investigation of Pollutant Source Strength— Rainfall Relationships at St. Louis*, in SEVENTH CONFERENCE ON INADVERTENT AND PLANNED WEATHER MODIFICATION 9 (1979) (American Meteorological Society, Banff, Alberta, Canada, Oct. 8-12, 1979).

as a disposal sink for industrial wastes has of course increased tremendously. The atmosphere has changed, is changing, and will change. It is a tremendous machine which has historically managed to absorb "insults" from volcanic eruptions to manmade intrusions, without long-term disturbance of an equilibrium.[15]

It is rapidly becoming apparent that certain activities of mankind are in the process of altering the world climatic balance. The implications of such alterations for a world where climate is an important part of a nation's well-being and where nations are increasingly armed with nuclear weapons are also becoming apparent. At least three issue areas require attention: (1) acid rain; (2) carbon dioxide and the "greenhouse" effect; and (3) the effect of chlorofluorocarbons (CFC's) on the ozone layer of the stratosphere.

Of these three issue areas, only one—acid rain—is of international concern, only because it affects many countries and the source of the problem is often in another nation. Acid rain does not appear to involve worldwide climatic effects. The other two—the increase of carbon dioxide in the atmosphere and the effects of CFC's on the ozone layer of the stratosphere—are truly global issues in that they both threaten change in the overall world climate and cannot adequately be ameliorated by the action of any one or even several countries. A worldwide response is clearly required.

A. *Acid Rain*

There is substantial evidence that acidity levels in precipitation have varied throughout history. Many natural sources such as volcanoes and forests increase the atmospheric loading of sulphur oxides, especially sulphur dioxide (SO_2), and nitrogen oxides (NOx) which, on chemical reaction in the atmosphere, precipitate as rain or snow containing higher acidity levels.

We have, however, come to realize two important sets of facts. On one hand, the greater the acidity of precipitation in an area, the more likely it is to cause erosion of stone surfaces of buildings and other structures, to harm crops, and to kill fish in ponds, lakes, and streams.[16] On the other hand, it now seems clear that many human activities—the burning of coal and oil, other industrial pursuits such as smelting, automobile exhaust, even farming—are adding substantially in various regions to the already present natural causes of acid precipitation or are creating new areas of acid precipitation damage.[17] Many of the effects of these

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15. This does not mean, of course, that atmospheric norms have not changed drastically over the countless years of the existence of the atmosphere.

16. *See* Ferenbaugh, *Acid Rain: Biological Effects and Implications*, 4 ENVT'L AFF. 745 (1975).

17. Other sources add to the quantities of both sulfur oxides and nitrogen oxides released into the atmosphere.

activities are felt in countries other than the source of the pollution.[18]

There is already widespread national and international concern about the effects of acid precipitation and about ways of dealing with them. As the United States moves increasingly to the use of coal to generate power, for example, increases in emissions may be anticipated unless steps are taken immediately to forestall adverse effects. Furthermore, remedies must be carefully evaluated. The introduction of very tall smokestacks may lead to a lessening of pollution in the immediate vicinity of the pollutant source, but it also places particulates higher in the atmosphere and makes it easier for them to travel great distances.

Before great strides can be expected internationally, countries with an avowed interest in pollution problems must be prepared to put "their own houses in order." Many nations have begun this process. The United States, among many other countries, has extensive legislation and regulations concerning the basic pollutants involved in acid rain. However, much more could be done. Permissible atmospheric releases of both SOx and NOx could be lowered. Research efforts could be increased. Coal washing could be made mandatory where appropriate. Use of tall stacks could be restricted. The worst offending plants could be phased out.

On the international level, an agreement between the United States and Canada, signed in August 1980, includes plans for major studies and recommendations for dealing with perceived perils.[19] The United States and Canada share major geographic areas where the underlying bedrock has a low capacity to buffer acids and is therefore susceptible to damage. John Fraser, Canada's Minister of the Environment, has called acid rain "the most serious environmental problem that Canada faces."[20] President Carter's 1979 Environmental Message recognized acid rain as a global threat of great importance and set up a ten-year Federal Acid Rain Assessment Program.[21] In 1977, the United States Clean Air Act was amended to make it clear that air pollution from the United States causing problems abroad could lead to a requirement of action by the states.[22] Thus, a beginning has been made on the North American continent.

In 1979, the Economic Commission for Europe (ECE), a United Nations regional organization with thirty-four members including the United States and Canada, promulgated the Convention on Long-Range Transboundary Air Pollution.[23] This Convention recognizes the necessity of in-

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18. There are at present substantial emissions in the northeastern United States, in southeastern Canada, and in northern Europe. Jackson, *supra* note 9, at 226-27.

19. Acid rain agreement, signed Aug. 5, 1980, by Secretary of State Edmund Muskie and Ambassador to the United States Peter Towe; *discussed in* 209 SCIENCE 890 (Aug. 22, 1980).

20. Speech of Nov. 2, 1979, Action Seminar on Acid Precipitation, Toronto, Canada.

21. 15 WEEKLY COMP. OF PRES. DOC. 1353, 1372-73 (Aug. 2, 1979).

22. 42 U.S.C. §§ 7401 *et seq.* (1977) (amending 42 U.S.C. §§ 7401 *et seq.* (1967)).

23. Convention on Long-Range Transboundary Air Pollution, *done* Nov. 13, 1979, 1 U.N. ECE, Annex I, U.N. Doc. E/ECE/HLM.1/2 (1979), *reprinted in* 18 INT'L LEGAL MAT.

ternational cooperation in monitoring and research. It is the first major direct acknowledgement of the issues. Despite the absence of a mechanism for compelling pollution abatement, the Convention calls for the joint development of air pollution control strategies. The parties pledge to make efforts "to limit, and as far as possible, gradually reduce and prevent air pollution."[24] This is a first step for Europe. It should be followed, in time, by additional agreements to establish the liability of nations for damage caused and to award compensation where appropriate.[25]

B. *Carbon Dioxide*

While the magnitude of our lack of knowledge and understanding about the chemical and other processes which take place in the upper atmosphere is appallingly large, the last few decades have witnessed dramatic gains in this area. Satellite probes, computers and computer modelling, and vast cooperative scientific programs covering large areas of the globe now make possible a better understanding of what the atmosphere is and how it functions. Such research has also made it possible to estimate the inroads and changes in the atmospheric commons which humans have made. Of the immediate insults to the environment (and to a decent life for humans), we can readily recognize the prevalence of such problems as smog in our cities and harmful acid rain. There are other, larger-scale effects which may be even more deleterious over time than these more visible, immediate examples.

For several decades, scientists have noted an increase in atmospheric carbon dioxide (CO_2). It is predicted that carbon dioxide in the atmosphere will about double in the period 1960 to 2030 (perhaps even to 2050).[26]

Since carbon dioxide tends to prevent the escape of heat from the earth, if this doubling occurs it could raise the global mean temperature of the earth some 1.5 to 4.5 degrees Celsius, with less warming at the Equator and more at the poles.[27] Shifts in the location of the earth's rain belts could also occur. While some nations might find their weather improved, others are certain to be worse off, and at this stage, no one can

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1442 (1979).

24. *Id.* art. 2.

25. A number of authorities have considered both the legal and biological causes and effects of acid rain. *See* Babich, Davies, & Stotzky, *Acid Precipitation: Causes and Consequences*, ENVIRONMENT, May 1980, at 6; Coppoc, note 9 *supra;* Ferenbaugh, note 16 *supra;* Graves, *Rain of Troubles*, SCIENCE 80, July/Aug. 1980, at 75 (includes Rosencranz, *International Forecast: More Acid Rain*, at 79); Likens, Wright, Galloway, & Butler, *Acid Rain*, SCIENTIFIC AM., Oct. 1979, at 43.

26. Becker, *Does a CO_2 Catastrophe Impend?*, 38 PUB. POWER 24, 25. *See generally* COUNCIL ON ENVIRONMENTAL QUALITY, GLOBAL ENERGY FUTURES AND THE CARBON DIOXIDE PROBLEM (1981); W. KELLOGG & R. SCHWARE, CLIMATE CHANGE AND SOCIETY: CONSEQUENCES OF INCREASING ATMOSPHERIC CARBON DIOXIDE (1981).

27. COUNCIL ON ENVIRONMENTAL QUALITY, *supra* note 26, at 8; KELLOGG & SCHWARE, *supra* note 26, at 45.

predict with certainty that anyone will be better off overall. Any improvements are hard to forecast and might not be net national benefits at all. Local gains might be overbalanced by planetary disasters.

Carbon dioxide enters the atmosphere from many natural sources. In addition, however, the advent of the industrial revolution led to a demonstrable increase in the atmosphere's CO_2 load. It is estimated that approximately three-fourths of the CO_2 in the atmosphere comes from the industrialized nations.[28] Less developed countries contribute a limited share by their own industrial processes. To a larger degree these countries contribute to CO_2 increases in the atmosphere by removing forests and burning the wood.

A CO_2-induced warming of the planet (in fact, any warming of the planet) would cause changes in the environment. Some areas may become more usable for farming. Other areas may lose warmth and moisture or may have too much heat for traditional crops. Increased heating at the poles may be enough to cause polar ice to melt with unpredictable climatic consequences. The West Antarctic ice sheet is considered less stable than other land-based ice and might melt, raising the earth's water level by perhaps ten feet. If this and the other Antarctic and Greenland ice sheets were to melt, water levels might rise as much as eighty feet worldwide. These are true catastrophes in the making. It is not that they are likely. It is simply that we can no longer ignore these possibilities.

A relatively limited number of countries are the major contributors to CO_2 emissions. They are also the primary beneficiaries of the industrialization which is based on the use of fossil fuels. The United States, the Soviet Union, and China are also the great sources of coal, the use of which will increase because of petroleum shortages. Only a few countries, such as Brazil, are the major holders of vast forest resources. Determined action by a relatively few states, therefore, could make a major contribution to changing the rate of CO_2 loading in the atmosphere. Individually, several of these nations have accepted the need to act. All question what steps should be taken. Few support any kind of international management or controls. Although the results of the "greenhouse effect" might not be observed for a century, the process having already begun may lead inexorably to unacceptable, perhaps even unforeseen consequences if actions are not taken in the immediate future. Without a beginning now, the processes may become irreversible.[29]

C. *Chlorofluorocarbons*

Chlorofluorocarbons (CFC's), perhaps best known under DuPont's

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28. M. TOLBA, THE STATE OF THE WORLD ENVIRONMENT 1980: THE 1980 REPORT OF THE EXECUTIVE DIRECTOR OF THE UNITED NATIONS ENVIRONMENT PROGRAMME (1980).

29. *See also* INADVERTENT CLIMATE MODIFICATION, note 9 *supra;* Bleicher, *An Overview of International Environmental Regulation,* 2 ECOLOGY L.Q. 1 (1972); Joyner & Joyner, note 9 *supra.*

trade name "freon," are a class of wonder chemicals. They are made up of extremely inert molecules which do not readily bond with others. They are versatile, nontoxic to humans, and are long lived. They have been widely used in aerosol spray cans, as industrial solvents, in air conditioning and refrigeration, and in foams used for cushioning, insulation, and packaging. They are the blowing agents used to make the cups and trays used by fast-food chains, for "plastic" egg cartons, and the like. They are also relatively inexpensive. The United States has accounted for about thirty percent of the world's emission of CFC's.[30] In 1976, this amounted to approximately 250 million pounds from nonaerosol applications.[31]

With all their good qualities, why are CFC's of current concern? In 1974, certain scientists first advanced the theory that CFC molecules, because of their inertness, rise to the stratosphere essentially unchanged. Once in the stratosphere, the sun's rays cause them to change and combine with molecules of ozone in a manner which lessens the ozone in the stratosphere. Since it is the ozone layer which shields humans, crops, animals, and life near the surface of the waters from damaging ultraviolet radiation, a decrease in ozone could lead to increases in skin cancer in areas of the earth where meteorological conditions and skin color make this disease an existent threat, not to mention damage to crops and other life forms. Moreover, another predicted result of CFC's in the stratosphere is an increase in the earth's temperature by the middle of the next century. By itself, CFC temperature increases are modest. When added to a CO_2 temperature-induced increase (an increase perhaps four times greater than that produced by CFC's alone), it assumes a far more serious potential for disruption.

One additional point warrants consideration. The escape of CFC's into the atmosphere is not limited to the time of their manufacture. Some escape slowly as the product is used, as in the case of rigid foams. Others are stored and released only when the product is discarded, as in the case of home refrigerators. This "bank" of CFC's is expected to grow rapidly over the decades unless a halt occurs now. While waiting, the quantity of CFC's is growing and will become increasingly more costly to police and control.

Reaction to the perceived long-range effects of CFC's remains mixed internationally. Some scientists suggest that further proof needs to be produced. This reluctance to act exists despite identification of the problem in authoritative reports issued by the National Academy of Sciences in 1977 and 1979, by the World Meteorological Organization, and by the staff of the United Nations Environment Programme (UNEP).[32]

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30. *See* NATIONAL ACADEMY OF SCIENCE, HALOCARBONS: EFFECTS ON STRATOSPHERIC OZONE (1976); *see also* NATIONAL ACADEMY OF SCIENCE, THE NATIONAL RESEARCH COUNCIL IN 1977 (1977).

31. *Id.*

32. Note 28 *supra.*

D. *Present International Safeguards Against Pollution*

Action to date has been primarily national, with the United States taking the lead by banning the use of CFC's in aerosol spray cans and by proposing overall limits on production. A few other nations, such as Canada, have acted as well. The Common Market countries have moved slowly. Scandinavian countries are taking action. The British and French have noted their doubts that there is as yet a demonstrable problem. There is a UNEP program in place for studying and monitoring the ozone layer. The critical question is whether these actions are adequate.

In the future, nations might enter into accords to set rules, to ban CFC's where appropriate, to use taxes and other incentive systems to limit their use, to regulate imports and exports, to encourage makers and users to find substitutes, and to use those CFC's which cause the least damage to the ozone layer. However, even before a worldwide consensus on this issue is developed, an agreement among the industrialized nations could dramatically change the outflow of CFC's.[33]

With both CO_2 and CFC's, the problem is truly global. The activities of one or even a small number of countries can have an immediate impact, but amelioration or a cure is ultimately the responsibility of all states. In each case, while the source of the problem exists in both present and future activities, actual "visible" proof of deleterious change may not be available for decades. Thus, for both CO_2 and CFC's, if preventative action is not begun at once, and on a broad scale, it is probable that the feared consequences will have occurred, or at least that the trend toward such consequences will be irreversible when they become widely perceived.

IV. CLIMATE MODIFICATION AND THE POTENTIAL FOR INTERNATIONAL CONFLICT

A common feature of all of the types of climate modification noted here is their potential for causing international tension and conflict. International modification of local weather, if it involves a border area, and of large scale storms (hurricanes, for example), is likely to be viewed as a "zero sum game,"[34] where one party loses if another gains. This may or may not be scientifically accurate, but *any* change may be perceived as a loss by some party. If the Chinese and Japanese governments advise the United States that a proposed typhoon suppression experimental program to be based on Guam is a potentially dangerous experiment, it is probably appropriate for the United States not to proceed, even if American scientists are certain that no effects could be felt in China or Japan. Once a typhoon was seeded, the United States would be blamed for *all* of its eventual damages regardless of whether the seeding could have con-

33. A range of activities resulting in impacts on the stratosphere is considered in chapter 9 of INADVERTENT CLIMATE MODIFICATION, note 9 *supra*.

34. Taubenfeld, *supra* note 5, at 494 n.10.

tributed to it.[35] With an operational experiment in the Gulf of Mexico, even unseeded and uninvestigated hurricanes led to claims by some Mexican politicians that the United States is "stealing" Mexico's rainfall.

Perhaps only a highly visible, truly internationalized experimental program could eliminate or dampen such a clamor. But what if it is proved that at least some modification efforts *do* cause certain losses? There is no mechanism for decision at the international level. Are states free to make choices having domestic benefits regardless of the effects of such choices on other nations? Who speaks in defense of the international "commons"—the seas, the atmosphere?

A. *Present International Legal Standards*

Although international law to date is embryonic at best, there is law in these areas. It is generally recognized as law that no nation may permit activities on its soil which will cause harm in another nation. In the classic case on this issue, the *Trail Smelter Arbitration*,[36] the tribunal was asked to deal with a smelter in British Columbia, and the effect of its pollution on properties in the state of Washington. Finding that damage was in fact being caused, the tribunal assessed damages and required that the pollution be monitored and diminished. While it did not, and could not, order the smelter to cease operations (a point worth noting for future cases), the tribunal did state that:

> [N]o State has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the properties or persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence.[37]

A similar but broader statement was made by the International Court of Justice in a dissimilar situation in *The Corfu Channel Case*[38] when the Court said that a state has an obligation "not to allow knowingly its territory to be used for acts contrary to the rights of other States."[39]

These ideas have been increasingly included in international instruments in the past several decades.[40] The 1972 Declaration of the United

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35. *Id.* at 496 n.19, 498-99 n.33.

36. The Tribunal gave a preliminary award on April 16, 1938, and the final award on March 11, 1941. Trail Smelter Arbitration (United States v. Canada), 3 R. Int'l Arb. Awards 1911 (1938); *id.* at 1905 (1941). The decisions of the Trail Smelter Arbitral Tribunal are also reported in 33 AM. J. INT'L L. 182 (1939) and 35 AM. J. INT'L L. 684 (1941). For an in-depth discussion of the case, see Rubin, *Pollution by Analogy: The Trail Smelter Arbitration*, 50 OR. L. REV. 259 (1971).

37. 3 R. Int'l Arb. Awards at 1965.

38. The Corfu Channel Case (Albania v. United Kingdom), [1949] I.C.J. 4.

39. *Id.* at 22.

40. The Helsinki Rules on the Uses of the Waters of International Rivers, for example, state that no nation can pollute so as to cause "substantial injury" to another nation and that the injured nation could call for abatement or compensation for damages. U.N. Doc. A/CN.4/274, *reprinted in* YEARBOOK OF THE INTERNATIONAL LAW COMMISSION, U.N. Doc. A/

Nations Conference on the Human Environment in Stockholm gave us several directly relevant principles relating not only to damage to another state but to the environment generally.[41]

For all sources of atmospheric modification, therefore, the basic norms have been stated and generally accepted. These norms apply regardless of whether the modification is intentional or not and whether it affects another nation specifically or the world's environment in general. No state may permit activities on its territories which seriously injure another state or its citizens, nor may it permit serious damage to the environment as a whole. Despite these principles and except for limited bilateral and special multilateral arrangements, there are now no widely accepted international mechanisms for resolving disputes as to scientific facts, for evaluating claims of injury and making binding awards, or for dealing with activities which affect the environment generally. In each case, some start has been made. Before reviewing progress to date and offering some suggestions for the future, however, one vitally important stumbling block in the path of any effective international control of pollution must be considered. This relates to the tension between development and the use of the atmospheric commons to dispose of the waste products of development.

CN.4/SER.A/1974/Add.1(Part 2), at 357; also *reprinted in* INTERNATIONAL LAW ASSOCIATION, REPORT OF THE FIFTY-SECOND CONFERENCE, HELSINKI 484, 496-97 (1966). *See generally* Bleicher, note 29 *supra*. Several other shared river and lake treaties are in accord. *See, e.g.*, The Indus Waters Treaty, Sept. 19, 1960, India-Pakistan-I.B.R.D., 419 U.N.T.S. 125; Agreement for the Full Utilization of the Nile Waters, Nov. 8, 1959, U.A.R.-Sudan, 453 U.N.T.S. 51; Treaty Relating to the Uses of the Waters of the Niagara River, Feb. 27, 1950, United States-Canada, 1 U.S.T. 694, T.I.A.S. No. 2130; Treaty Relating to the Utilization of the Waters of the Colorado and Tijuana Rivers, and of the Rio Grande, Feb. 3, 1944, United States-Mexico, 59 Stat. 1219, T.S. No. 994.

41. Principle 6, for example, expressly states that:

> The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems . . . .

This concept is later reinforced in Principles 21 and 22:

> Principle 21. States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.
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> Principle 22. States shall co-operate to develop further the international law regarding liability and compensation for the victims of pollution and other environmental damage caused by activities within the jurisdiction or control of such States to areas beyond their jurisdiction.

Report of the United Nations Conference on the Human Environment (Stockholm, 5-16 June 1972), 1 U.N. GAOR (21st plen. mtg.), U.N. Doc. A/CONF.48/14 Rev.1 (1972) *reprinted in* 11 INT'L LEGAL MAT. 1416 (1972) [hereinafter cited as Stockholm Conference on the Human Environment]. *See also* Sohn, *The Stockholm Declaration on the Human Environment*, 14 HARV. INT'L L.J. 423 (1973).

B. *Industrialization in the Developing Countries*

Just as the United Nations has recognized the damage of pollution both to the human environment and to peace between neighbors, it has also firmly and repeatedly recognized a "right" to development. Although this right is often asserted by the less developed nations, the more developed nations also support the goals of development. While the more industrialized nations acknowledge the inherent instability caused by tensions between rich and poor, they seemingly trust the apparent efficacy of development and industrialization as the "invisible hand" in the eventual self-limitation of population growth, and hope that development will help in the alleviation of disease, starvation, infant mortality, and short life expectancy.

Scientists and decisionmakers in many of the more developed countries have, however, become increasingly aware of the dangers to the environment the industrial revolution has created. Through the traditional free use of waters, oceans, and the atmosphere as dumps for our wastes, we endanger not only our countries and ourselves, but also our neighbors and, potentially, the very survival of human life. We are thus presented with a dichotomy. Industrial development has resulted in vastly increased health, well-being, and life expectancy for most humans in those countries which are already well on the path of industrialization. Conversely, industrialization also brings threats to those it helps and to the world environment.

Since it is clear that countries will industrialize, we need to devise strategies immediately to begin to cope with potential consequences even if they are decades away. We need to understand, to accept, and to plan for a world in which there are tensions between development (which means burning more fossil fuels, cutting more forests, using marvelous products like CFC's) and the more general but eventually overwhelming need of environmental survival.

V. FUTURE WORLD ORDER

A. *Protection of the International "Commons"*

As we turn to the future, it seems clear, at least in principle, that the international "commons" must be protected from harmful activities arising in any state. The effects of large-scale industrialization, the omnipresence of the automobile, the increasing knowledge of the deleterious effects of many waste materials, acid rain, smog, high level atmospheric pollution—all this has led not only to discussion and studies but to legislation and the creation of domestic and international mechanisms for problem solving. The efforts thus far are limited. Not all countries are concerned. Not all problems are recognized as problems. Nevertheless, while it would be unwise to assume that, internationally, all nations are realistically assessing the potential problems or even that they have moved forcefully to cope with existent and demonstrated perils, it would also be foolish to ignore the important steps that have already been

taken.

In the United States, activities have included the creation of and the decade of work by the Environmental Protection Agency (EPA). Water and air quality are monitored, research is intense, and standards have been set. From its origins, the EPA has been concerned with international issues. As Senator Henry Jackson, the principal author of the National Environmental Protection Act, said on the Senate Floor, the Act is a "congressional declaration that . . . we will not intentionally initiate actions which will do irreparable damage to the air, land and water which support life on earth."[42] The Act applies to the entirety of the "human environment," including "international aspects."[43]

On the issues of potential international concern, efforts have been focused on the amelioration of CO_2 and acid rain problems, and vigorous action has been taken with respect to CFC's. The use of CFC's in aerosol spray cans has been prohibited and regulations limiting overall production are being developed.[44] Several other countries have also taken action to limit the escape of the chemical contributors to acid rain and to cut back air and water pollution.[45] Several countries have followed the United States' lead to limit the movement of CFC's into the stratosphere.[46]

Bilaterally, the United States has been working with Mexico on water and air quality problems,[47] and with Canada on the problems of water use, water pollution, and acid rain.[48] The United States, France,

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42. 115 CONG. REC. 40416 (1969).

43. The National Environmental Policy Act § 102(2)(C) (1969) (current version at 42 U.S.C. §§ 4321 *et seq.* (1976 & Supp. III 1979). *See also* H.R. REP. No. 378, 91st Cong., 1st Sess. 7 (1969).

44. In March 1978, the EPA and the FDA issued bans on the use of CFC's in aerosol applications. The ban became effective Oct. 15, 1978. Exemptions from the general prohibition on manufacture, processing and distribution as well as essential use and special exemptions are discussed in 40 C.F.R. §§ 762.45 *et seq.* (1981). The FDA has promulgated separate regulations on the use of CFC's in articles at 21 C.F.R. § 2.125 (1978).

45. Bleicher, *supra* note 29, at 44-45 nn.177-78, where various reports and problems of Norwegian "black snow" are discussed.

46. Sweden, Norway and Canada have enacted the most comprehensive limitations on the manufacture of CFC's. Concern has been expressed in Germany and the Netherlands.

47. Agreement of Cooperation Regarding Pollution of the Marine Environment by Discharges of Hydrocarbons and Other Hazardous Substances, July 24, 1980, *entered into force* Mar. 30, 1981, United States-Mexico, *noted in* 81 DEP'T STATE BULL. 61 (June 1981); Memorandum of Understanding for Cooperation on Environmental Programs and Transboundary Problems, June 14-19, 1978, United States-Mexico, 30 U.S.T. 1574, T.I.A.S. No. 9264; Agreement on the Permanent and Definitive Solution to the International Problem of the Salinity of the Colorado River, Aug. 30, 1973, United States-Mexico, 24 U.S.T. 1968, T.I.A.S. No. 7708; Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, *opened for signature* Dec. 29, 1972, 26 U.S.T. 2403, T.I.A.S. No. 8165 *entered into force* for the United States, Aug. 30, 1975.

48. Agreement on Great Lakes Water Quality, Nov. 22, 1978, United States-Canada, 30 U.S.T. 1383, T.I.A.S. No. 9257; Agreement on Contingency Plans for Spills of Oil and Other Noxious Substances, June 19, 1974, United States-Canada, 25 U.S.T. 1280, T.I.A.S. No. 7861.

and the United Kingdom are parties to an innovative treaty on monitoring the stratosphere.[49] European countries have entered into several bilateral and multilateral agreements to curb pollution, especially in multinational lakes and rivers.[50] As discussed above, the ECE promulgated a treaty on transfrontier, long-range, airborne pollution.[51] The Scandinavian countries are not only cooperating nationally with respect to transborder pollution, but have also opened their courts and administrative mechanisms to citizens of neighboring states affected by pollution.[52]

B. *Progress in International Institutions*

At an even broader level, the United Nations, while stressing the right of each nation to develop, has adopted resolutions pointing out the need to limit the dangers from pollution.[53] The U.N. Environment Programme (UNEP) has been given a special role as overseer of the international programs concerning the ozone layer. Other agencies, including *inter alia* the World Meteorological Organization (WMO), the World Health Organization (WHO), and the Food and Agriculture Organization (FAO), have special assignments as part of the effort to assess the state of the upper atmosphere and to find indications of change while there is still time to act. Such nongovernmental scientific agencies as the International Council of Scientific Unions (ICSU)[54] have also played important roles in advancing our knowledge and, therefore, in contributing to issue identification and potential resolution.

VI. CONCLUSIONS

Despite these signs of progress, the international record in preserving and sharing resources is not good. The potential loss of the great whales due to human rapaciousness, despite international efforts to preserve them, is a case in point. Perhaps what is now needed is a dual strategy,

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49. Agreement on Monitoring of the Stratosphere, May 5, 1976, United States-France-United Kingdom, 27 U.S.T. 1437, T.I.A.S. No. 8255, *reprinted in* [1978 Reference File] 1 INT'L ENVIR. REP. (BNA) ¶ 21:2501.

50. Convention for the Protection of the Rhine Against Chemical Pollution, *done at* Bonn, Dec. 3, 1976, *reprinted in* 16 INT'L LEGAL MAT. 242 (1977); Convention on the Protection of the Rhine Against Pollution by Chlorides, *done at* Bonn, Dec. 3, 1976, *reprinted in* 16 INT'L LEGAL MAT. 265 (1977); The Nordic Convention on the Protection of the Environment, *done at* Stockholm, Feb. 19, 1974, *reprinted in* THE NORDIC ENVIRONMENTAL PROTECTION CONVENTION, WITH A COMMENTARY (Swedish Royal Ministry for Foreign Affairs and Royal Ministry of Agriculture), *also reprinted in* 13 INT'L LEGAL MAT. 591 (1974) [hereinafter cited as The Nordic Convention].

51. Note 23 *supra*.

52. The Nordic Convention, *supra* note 51, art. 3.

53. Stockholm Conference on the Human Environment, note 42 *supra*.

54. The International Council of Scientific Unions together with the World Meteorological Organization are partners in preparing, coordinating and directing a major international study, the Global Atmospheric Research Program. Taubenfeld, *supra* note 3, at 323. For a discussion of the 9 scientific committees and 16 scientific unions within ICSU, see Joyner & Joyner, *supra* note 9, at 551-52 n.93.

one which would press forward along the lines of observation, monitoring, fact-finding, standard-setting and, eventually, enforcement at an international level, while at the same time we search for techniques which would permit humanity a decent environmental future.

We should press forward vigorously in each nation to continually set the highest standards of environmental protection consonant with decent survival and progress. We should press for a growth of international activities in monitoring and, in time, in developing stringent rules for national action. Uniform rules may well help an enterprise avoid a competitive disadvantage if other enterprises are not obligated to take steps to avoid pollution. Over time, effective rules should be developed and upheld by national courts and, perhaps, by the International Court of Justice or by a new environmental law tribunal for assessing facts and awarding recompense.[55]

It must be noted, as some scientists are now pointing out, that climatic change is inevitable. If humanity disappeared, climate would still change over time. Mankind may be benefited or harmed by a particular change, and it is appropriate to prevent where possible human-induced damaging change. However, change is the order of the universe. Because of this fact, it is appropriate to urge decisionmakers in all nations to give present and continuing attention to strategies which accept very long-term change in climate as certain, and to work to reduce the risks of damage to humanity from such changes. Cooperation in developing weather modification techniques, stronger, more resistant crops, cattle with better tolerance for temperature and moisture changes, programs for improved storage of crops, cooperation in distribution of necessities worldwide, and assistance in alternative programs of development, could make nations more immune from climatic change.

There is clearly room for the wider use of international agencies (UNEP, WMO, WHO, FAO, and others) while a general agreement or agreements could be promulgated through the United Nations General Assembly or at special conferences. This is not a plea for a technological "fix" which would obviate the need for the control of pollution, for preserving the atmosphere, or for trying to cope directly with insults to the environment. Indeed, we need to develop international regulation and control as rapidly as we can. The rate and magnitude of man-made changes in the world environment may already be exceeding our capacity to cope effectively. What is proposed is a dual strategy. Solutions to our environmental problems will come slowly. We need to move to protect against human impacts on the environment *and* to ameliorate future conditions regardless of the cause.

In general, we can point with pride to certain major national and

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55. *See* Sigel, *supra* note 2, at 576. For a discussion of incidents involving transnational airborne pollution that have been referred to the International Court of Justice, see Bleicher, *supra* note 29, at 44 n.174.

international efforts to identify dangers to the human "commons" and, primarily on a national basis, to cope with them. Since the problems are global, multinational efforts to control transfrontier pollution and assaults on the atmosphere are essential. No single nation can do it alone. These efforts have begun, but the conflicts of interest are very real.

International cooperation must be forcefully pursued with assurance for the less developed nations (or for any nation especially affected) of favorable terms for pollution-free or pollution-moderating technology, for substitute goods, or for whatever it takes to encourage development while safeguarding the human future. Perhaps then we can face the future with some degree of certainty. Still, if there comes to be recognized a true crisis of the environment, threatening the lives of all or most humans or at least requiring strict rationing of the right to industrialize, then major changes in the present world system would be required. We would in that case need something like a responsible world government with the ability to assure the equitable distribution of the rights to life, to material welfare, and to security.