

GLOBAL AIR POLLUTION AND THE GREENHOUSE EFFECT: CAN INTERNATIONAL LEGAL STRUCTURES MEET THE CHALLENGE?

I. INTRODUCTION

World industrialization and population increases have generated major changes in human activities. More and more, waste products of these activities place global rather than local stresses upon the earth's environment. Acid rain, ozone depletion problems, and global warming or the "greenhouse effect" threaten the entire world's atmosphere.¹ Traditional legal channels have become inadequate, particularly in preventing future harmful activities. Of necessity, international organizations have evolved to create forums for resolution of environmental disputes, and to foster scientific study of the problem. Early international response focused on recognition of global impacts of the air pollution crisis and emphasized data collection.²

1. Scientific studies suggest that many effects of pollution may be irreversible. These studies include: NASA GODDARD INSTITUTE FOR SPACE STUDIES, GLOBAL CLIMATE CHANGES AS FORECAST BY GISS 3-D MODEL (1988) (presented by J. Hansen before the Senate Committee on Energy and Natural Resources, 100th Cong., 1st Sess. 84 (1988)), *see infra* note 45; WORLD METEOROLOGICAL ORGANIZATION (WMO) AND THE UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP), DEVELOPING POLICIES FOR RESPONDING TO CLIMATIC CHANGE (1987)[hereinafter BELLAGIO REPORT, *see infra* note 133]; and major studies coordinated between the World Resources Institute, Climate, Energy and Pollution Program (WRP), the International Institute for Environment and Development (IIED), and UNEP, using the Global Environment Monitoring System established by UNEP. These last studies are set forth in WORLD RESOURCES INSTITUTE, INTERNATIONAL INSTITUTE FOR THE ENVIRONMENT AND DEVELOPMENT 1986 [hereinafter WRI 1986], and WORLD RESOURCES INSTITUTE, WORLD RESOURCES 1988-1989 [hereinafter WRI 1988-89]. *See infra*, note 153.

2. An early effort to enhance awareness is the Report of the United Nations Conference on the Human Environment, U.N. Doc. A/Conf. 48/14 (1972), *reprinted at* 11 I.L.M. 1416 (1972). Principle 21 of this "Stockholm Declaration" sets forth that a state shall not cause damage to other states or areas beyond its jurisdictional limits, which impliedly extends to the "common property of mankind" (i.e., the high seas, Antarctica, and outer space). A.C. KISS, SURVEY OF CURRENT DEVELOPMENTS IN INTERNATIONAL ENVIRONMENTAL LAW 47 (1976) [hereinafter KISS SURVEY]. The Stockholm Conference was limited in impact because only a declaration rather than a binding resolution or treaty was issued. The USSR and most of the Eastern Bloc of Socialist States boycotted the meeting because of the West's refusal to admit East Germany. A major segment of the world community was therefore not even "morally bound" to adhere to the Stockholm principles. *See Comment, The Problem of Ozone Depletion—Is There An International Legal Solution?*, 12 N.C.J. INT'L & COM. REG. 433, 442 (1987) [hereinafter *Ozone Depletion*].

Finding solutions to air pollution issues poses special problems for international law. Often the detrimental effects of the pollution are not immediately apparent, but rather manifest only after extended periods of time. Moreover, the offending party or source of the pollution is often not readily discernible.

Even if both effects and sources of the pollution are identifiable, other major legal obstacles impede successful lawsuits that might otherwise function effectively as deterrents. Questions arise as to who may sue, an individual or a state, and on whose behalf. Similarly, questions arise as to who may be sued. A state's liability for the acts of individual polluters is dubious unless "assumed responsibilities" exist because of contract or treaty.³ Involvement of a non-national, either as polluter or victim, exacerbates the issues greatly.⁴ Once problems of standing and proper parties are resolved, governing law must be determined. Conflicts of law issues are serious as they affect the existence of substantive legal bases to bring the suit.

Even if all these problems are successfully addressed, actual proof problems may remain insurmountable. The nature of air pollution, complicated by complex wind patterns, can render establishment of causation nearly impossible.⁵ Moreover, in many cases the technological methods needed to gather necessary proof data, and to package that data in a form amenable to the legal system, simply do not exist.

Finally, if the lawsuit is successful, applicable law may lack an adequate remedy or the means of enforcement. Often a victim may be compensated only for direct damages; rarely will an injunction be issued.⁶ Actual enforcement is further hindered because much of international law is "soft," with no means to compel compliance.⁷ Any binding, enforceable law is most frequently the product of a treaty, and thus depends upon a voluntary assumption of liability.⁸

3. It is also possible that obligations arise independently of the will of the obligated party. I. BROWNLIE, *PRINCIPLES OF PUBLIC INTERNATIONAL LAW* 184, 190-210 (1966).

4. *Id.* at 394-95.

5. Bin Cheng discusses the two criteria, objective and subjective, used to determine proximate cause and liability in tort. The objective criterion looks for normal and natural results, without concern that these be direct or indirect. The subjective criterion looks for reasonable foreseeability and intent. The causal connection is particularly difficult to establish in environmental issues; the chief object of many various studies is to establish this causal link through increased probability (science) and foreseeability (dissemination of information). B. CHENG, *GENERAL PRINCIPLES OF LAW AS APPLIED BY INTERNATIONAL COURTS & TRIBUNALS* 241-49 (1987).

6. If specific damages cannot be proven, material or moral, no indemnity can be awarded. It is possible to get a declaratory judgment to determine legality or clarify respective rights of parties. *Id.* at 236.

7. KISS SURVEY, *supra* note 2, at 41.

8. There is a growing implication that liability can occur for omissions of specific

Not surprisingly, lawsuits against international polluters are infrequent and prospects for success are slight. However, recent developments in international law suggest a more promising future.

International agreements and organizations designed to specifically address issues of air pollution are coming into existence. The Montreal Protocol, which sets forth compliance standards for especially dangerous emissions, is a prime example.⁹ Moreover, nations are increasingly abandoning policies of nonintervention¹⁰ and stressing the "Good Neighbor" policy which emphasizes protection of neighboring countries,¹¹ including the quality of the neighbors' air.¹² More sophisticated data collection equipment and techniques also mean that polluters are more likely to be detected and that proof will be available for court.

This paper will trace the evolution of international law as it has responded to the increasingly global impact of air pollution. After an analysis of the primary chemical compounds of concern and their effects, the paper will examine traditional means of dealing with activities harmful to the atmosphere. Next, the growth of international legal structures specifically designed to address these issues and facilitate prevention and enforcement will be examined. Throughout, it will be stressed that recent development of legal organizations and changes in substantive law, coupled with technological advancements, enhance the

international obligations, grounded in due diligence theory, and not only for performance of ultra-hazardous activities. KISS SURVEY, *supra* note 2, at 41, 49, 52, 54. However, due diligence addresses only the state's failure to act as required by international law, and does not apply to positive, negligent acts. What is more, no specific rules forbid environmentally harmful activities and no international norms exist setting forth the best means or methods to meet the obligation of due care that no damage be inflicted on other states' environment. Establishment of a wrongful omission is difficult, so this basis of action is seldom useful. I. VAN LIER, ACID RAIN AND INTERNATIONAL LAW 104 (1980).

9. Montreal Protocol on Substances that Deplete the Ozone Layer, Sept. 16, 1987, *reprinted in* 26 I.L.M. 1550 (1987) [hereinafter Protocol].

10. A.C. KISS, LEGAL ASPECTS OF AIR POLLUTION CONTROL 18 (1972).

11. Corfu Channel (Greece v. Italy), 1949 I.C.J. 18, sets out that "every state is under an obligation . . . not to allow its territory to be used for acts contrary to the rights of other states."

12. B. CHENG, *supra* note 5, at 21, 23-24, 166. Trail Smelter Arbitration (U.S. v. Can.), 3 R. INT'L ARB. AWARDS 1907 (1949). The decisions were dated April 16, 1938 and March 11, 1941. KISS SURVEY, *supra* note 2, at 43. A.C. Kiss, Director of Research Centre National de la Recherche Scientifique and Professor of International Law at the University of Legal Political and Social Sciences at Strasbourg, France, and one of the founders and former President of the European Council of Environmental Law, states regarding the Trail Smelter Case: "One cannot emphasize enough the importance of the Conclusion of the arbitrators in this the only case concerning international liability for transfrontier environmental injury, namely that regulations had to be established and the two concerned States had to cooperate in order to prevent future injuries to the environment." KISS SURVEY, *supra* note 2, at 55.

international legal community's capacity to effectively address international air pollution.

II. HAZARDOUS CHEMICALS, THEIR SOURCES, AND THEIR EFFECTS ON THE ENVIRONMENT

A. Chemical Compounds of Primary Concern and Their Sources

Suspended particulate matter (SPMs) have many natural sources (i.e. soil and dust), but artificial sources are of greater concern because they carry toxic trace substances or are themselves toxic. Fine particulates (aerosols) can be formed in the atmosphere from gaseous emissions, creating secondary pollutants. Their sources include industrial processes and fuel combustion (especially diesel engines).¹³

Acid deposition and acid rain are caused by complex reactions in the atmosphere. Sulphur dioxide and nitrogen oxides are transformed, under the certain conditions, into sulfuric and nitric acids. Two-thirds of atmospheric acidity is from sulphur and one-third is from nitrogen.¹⁴ Ninety percent of sulphur dioxide emissions are man-made. These emissions originate principally from coal and oil at power plants, and secondarily from other industrial processes.¹⁵ Nitrogen oxides result primarily from fuel combustion in the transportation sector. These oxides create yellow smog and contribute to oxidant (ozone) formation.¹⁶ In addition, ninety percent of carbon monoxide is also generated by the transportation sector.¹⁷

Acid deposition can be dry (which occurs near the sources) or wet (which can travel great distances). In areas of heavy industrial concentration, fifty percent of the acid deposition is dry. Fifty percent of acid deposition worldwide occurs from natural sources, but in heavily industrialized regions, such as Europe and northeastern North America, ninety percent is derived from man-made sources.¹⁸ This deposition frequently takes the form of acidic precipitation. In Europe, efforts to monitor the effects of acid rain are the most thorough.¹⁹ Sulfate deposition has

13. WRI 1986, *supra* note 1, at 163-64.

14. *Id.* at 167.

15. *Id.* at 162.

16. *Id.* at 164-65.

17. *Id.* at 166.

18. *Id.* at 168.

19. North America has not kept pace with monitoring efforts in Western Europe where the problem has become a major issue. There are twelve monitoring sites in Scandinavia alone. Outside Western Europe and North America, data on acid deposition are sparse. WRI 1986, *supra* note 1, at 169. The proposed accord between the United States and Canada would provide for an improved research and monitoring program. Houston Chron., July 9, 1990, at 4A, col. 5.

decreased or stabilized, but nitrate concentrations have increased since the 1960s.²⁰

Levels of ozone concentration affect the heating rates of surface temperatures, air movements, and downward emissions of infrared radiation by absorbing heat radiated from the earth.²¹ Ozone concentrations are affected by reactions with oxygen, nitrogen, chlorine and hydrogen oxides. Major sources of concern include:

- (1) carbon dioxide (which increases stratospheric ozone and is a product of fossil fuel combustion as well as biomass burning);²²
- (2) chlorofluorocarbons (CFCs) (found in aerosol propellants, refrigeration compounds, foam-blown plastics including fast-food containers, and solvents);²³
- (3) methane (released to the atmosphere through biomass burning and during production of coal and natural gas);²⁴
- (4) nitrous oxides (these compounds decrease ozone but have localized effects which vary with the altitude injection; for example, airplane exhaust gas). These compounds are emitted from fertilizer applications and combustion of biomass and fossil fuels.²⁵

Stratospheric ozone (twenty to twenty-five kilometers above the earth's surface) shields the earth from ultraviolet radiation by absorbing harmful wavelengths. Tropospheric ozone (ozone close to the earth's

20. WRI 1986, *supra* note 1, at 167-68.

21. *Id.* at 172-73.

22. Different fossil fuels release different amounts of carbon. Natural gas produces about one-half the carbon that coal does for each unit of energy. Coal, although producing only 35% of the world's energy, produces 41% of the world's carbon dioxide. Lester & Myers, *Global Warming, Climate Disruption, and Biological Diversity*, 1989-1990 AUDUBON WILDLIFE REPORT 184 (1990) [hereinafter AUDUBON].

23. CFCs have a very strong greenhouse effect, with extremely long atmospheric lifetimes. *Id.* at 185. These chemicals have been the target of most recent international agreements, including the Montreal Protocol. CFCs, halons, and carbon tetrachloride have already destroyed 3% of the global ozone. Wall St. J., June 29, 1990, at A7, col. 2.

24. WRI 1986, *supra* note 1, at 174. "Methane is produced by anaerobic bacteria in the anoxic sediments of rice paddies and in the stomach of cattle and other ruminants." AUDUBON, *supra* note 22, at 181-86. Methane concentrations since 1965 have increased due to expanded rice paddy cultivation, more domestic ruminants, and other land use changes. Recent evidence also suggests deforestation may be a principal source of increased atmospheric methane. Deforested lands are often converted to agricultural uses, and also provide good habitat for methane-producing termites. *Id.* at 184, citing Mooney, *Exchange of Materials Between Terrestrial Ecosystems and the Atmosphere*, 238 SCIENCE 926-32 (1987).

25. WRI 1986, *supra* note 1, at 171-76.

surface) damages plants and human health. Ozone-affecting chemicals impact both the stratosphere and the troposphere.

B. *The Effects of Chemicals on the Earth and its Atmosphere*

Sulphur dioxide and SPM pollution levels are measured by the Global Environmental Monitoring System (GEMS) network at fifty-two stations.²⁶ Thirty percent of the stations recently reported a decrease in pollution levels, twenty percent reported no real changes, and none reported upward trends for both pollutants. Unusually high levels have been reported in Iran and India, reflecting the high dust levels in those regions.²⁷

Third World countries and Eastern Europe are consistently more polluted by SPM than most cities in Organization for Economic Cooperation and Development (OECD) countries.²⁸ With the exception of Milan, all of the worst-polluted cities that report data to GEMS are in developing countries. There are several dozen GEMS stations in Latin America and Asia, including twenty stations in China; only a few stations are located in Africa. SPM levels exceeded the World Health Organization's recommended standards at sixty-two of the seventy-three monitoring stations in developing countries. In some South American cities, SPM levels exceeded the standards by a factor of two, and SPM levels in some Asian cities exceeded the standards by factors of three to five.²⁹

The causes of this pollution vary. For example, in Beijing, China, household coal-burning is largely responsible.³⁰ In São Paulo, Brazil, industrial emissions are largely responsible.³¹ Smoke and suspended

26. UNEP has become an information base for an air quality network, in cooperation with the World Health Organization (WHO). "As of 1980 the UNEP Global Environmental Monitoring System (GEMS) network consisted of about 136 sites in 33 countries, but since then it has expanded considerably." Most monitoring sites are located in the OECD countries of Europe, North America, and the Pacific. Many new sites are located in Third World cities but data is not yet available from all of these sites. *Id.* at 161.

27. Alarming high smoke concentrations in several South American countries have also been reported since 1975. *Id.* at 164.

28. The Third World houses most of the world's population which forces increasing demands for energy, food, and natural resources. Emissions of CO₂ and other pollutants are higher due to the much greater energy usage per capita. Lester & Myers, *Global Warming, Climate Disruption, and Biological Diversity*, 1989/1990 AUDUBON, *supra* note 22, at 176, 186.

29. WRI 1988-89, *supra* note 1, at 171.

30. In winter, 1.5 million small coal-fired furnaces and household stoves emit 22 tons of particulates per day, and also contribute up to 72% of the city's CO₂ concentrations. *Id.*

31. More than forty-five thousand industrial enterprises are located in the greater São Paulo region. *Id.*

particulate pollution in these areas are particularly serious. These pollutants are no longer seen as a problem of the industrialized world alone.³²

Nitrogen oxide levels are stable in OECD countries, with some decreases in the United States. This chemical affects ozone levels, accelerates forest decline, and has a major impact on human health. Most significantly, it contributes to acid rain.³³ Toxic pollutants (mentioned above with SPMs) are unconventional trace pollutants, the byproducts of various industrial activities. These "wild cards" are not routinely monitored or documented. Thus, their effects on all life forms are unknown.³⁴

Acid rain affects lakes, waterways, snow melt, and runoff. Acid deposition and acid rain have caused acidification of aquatic ecosystems. This leads to the disruption of entire life cycles and has resulted in devastating fish kills in North America and in Europe.³⁵ Some lakes in North America and Europe can no longer support aquatic life due to acid rain.³⁶

Early records of the damage to fish populations focused on adult game fish, instead of on the more sensitive juvenile fish and organisms lower in the food chain.³⁷ In Norway, it was found that seventy-four percent of the brown trout and fifty-three percent of the perch had disappeared since the 1950s.

Another major side-effect of the increased acid levels is the increased toxicity of aluminum. Aluminum is released into lakes and streams from acidified soils and sediments which are washed into them by rain and snow runoff. This, in turn, causes the pH level to fall. When the pH level falls to about five, aluminum becomes lethal to fish.³⁸ This toxicity affects major human food sources by killing the smaller organisms which support life in lakes and waterways. A chain reaction can cause larger organisms to die of starvation even before they are affected by toxicity. The ultimate results are "dead" lakes and waterways, unable to support life on land or in the air.³⁹

32. *Id.*

33. WRI 1986, *supra* note 1, at 166.

34. *Id.* at 166-67.

35. Decreased pH levels have been reported throughout Europe and the eastern portion of North America. WRI 1986, *supra* note 1, at 169-71.

36. WRI 1988-89, *supra* note 1, at 172. Canadian government statistics show that in eastern Canada, 14,000 lakes are acidified, 150,000 others are damaged, and 300,000 are vulnerable. Houston Chron., July 9, 1990, at 4A, col. 6.

37. WRI 1988-89, *supra* note 1, at 172.

38. *Id.* at 171.

39. *Id.* at 172.

Acid rain has also been found to cause degradation and corrosion to monuments, memorials, and statues. This has been felt especially in Europe. Most of the damage is the result of the sulphur dioxide found in acid rain.⁴⁰ Serious declines in forests have also been observed as a result of acid deposition and rain, particularly in Europe, Scandinavia, the United States, and Canada.⁴¹ The primary problem is that gaseous sulphur can remain suspended in the atmosphere for hours or weeks while winds transport it long distances. In Europe and in eastern North America, recent studies indicate that one-third of the acidic soil deposits are from sources over 500 kilometers away, one-third are from sources 200-500 kilometers away, and the remaining one-third are from sources within 200 kilometers of the deposition site. This results in extremely complicated and severe exchange problems between nations.⁴²

Recently, ozone concentrations have received widespread attention. Dr. Ralph Cicerone, Director of the Atmospheric Chemistry Division of the National Center for Atmospheric Research, has estimated that one-third of the greenhouse effect may be attributed to CFC emissions.⁴³ The current growth in CFC emissions will reduce total ozone concentrations in the stratosphere enough to allow increased amounts of ultraviolet radiation to reach the earth. This increase in radiation can cause non-melanoma skin cancers, suppression of human immunological systems, damage to plants and animals (such as important species of cattle), and aggravation of the greenhouse effect.⁴⁴

Estimates on the rate of ozone depletion vary.⁴⁵ Significantly, however, a March 1988 study showed a larger ozone loss than had previously been predicted.⁴⁶ The study was a collaborative effort of

40. WRI 1986, *supra* note 1, at 171.

41. Large areas in and downwind from major emission areas have experienced precipitation averaging pH 4.2-4.5. "Rainfall can be as acidic as pH 3 (vinegar). One rainstorm in Wheeling, West Virginia had a pH of 1.5 (battery acid has a pH of 1)." *Id.* at 168. Over fifty percent of the forests in eastern Canada are threatened, affecting a major source of money and jobs. *Houston Chron.*, July 9, 1990, at 4A, col. 6.

42. WRI 1986, *supra* note 1, at 168.

43. This was a 1985 estimate. *Ozone Depletion*, *supra* note 2, at 433, 438.

44. WRI 1986, *supra* note 1, at 172-73.

45. According to the different scenarios presented in the GISS 3-D model, levels will vary depending upon various action or inaction taken to reduce trace gas emissions. All models, however, indicate future global warming. *Greenhouse Effect and Global Climate Change, Hearings before the Senate Committee on Energy and Natural Resources*, 100th Cong., 1st Sess. 42, 50 (1988) [hereinafter *Hearings*] (statement of James E. Hansen, NASA Goddard Institute for Space Studies, Attachment A). One study predicts that as current CFC emissions increase, the earth's surface temperature will warm up by two to four degrees Centigrade by the year 2030. This would result in a rise in sea water level of four and one-half feet or more. Comment, *Thinning Air, Better Beware: Chlorofluorocarbons and the Ozone Layer*, 6 DICK. J. INT'L L. 87, 93 (1987). See *infra* note 66 and accompanying text.

46. OZONE TRENDS PANEL, NATIONAL AERONAUTIC AND SPACE ADMINISTRATION, EXECUTIVE

more than one hundred scientists, and is one of the most authoritative to date. The study was so compelling that after its release, E.I. DuPont Company, the largest manufacturer of CFCs in the world, announced it would phase out production of ozone-depleting CFC formulations.⁴⁷

Human activities also affect the global mean temperature which results in the greenhouse effect.⁴⁸ The greenhouse effect occurs from the release of gases which absorb outgoing radiation. This increases atmospheric concentrations (including increases in tropospheric ozone) and causes a warming of the surface and the lower atmosphere. Analyses of these observations suggest that the global mean temperature appears to have increased 0.3-0.7 degrees Centigrade in the last one hundred years.⁴⁹

Carbon dioxide (CO₂) is the major contributor to this greenhouse warming trend. CO₂ emissions stem primarily from fossil fuel combustion created by the transportation sector and other industrial sectors. However, these emissions are also a by-product of deforestation, burning and land-use changes. There has been a twenty-five percent increase in CO₂ concentrations over the last one hundred years, with the greatest acceleration of levels occurring in the last thirty years.⁵⁰ "Rapid growth in energy and fossil fuel consumption could lead to a doubling of CO₂ by about the year 2040; a low CO₂ emission scenario could postpone such a doubling until after the year 2100."⁵¹ Controlling the rate of increase in CO₂ is very important if the rate of global warming is to be minimized and controlled.⁵² Controversy over this issue still exists and results in differing national policies, urging either immediate action or further delay.⁵³

SUMMARY OF THE OZONE TRENDS PANEL (1988). WRI 1988-89, *supra* note 1 at 178, 180.

47. WRI 1988-89, *supra* note 1, at 178. Contrast this with the earlier 1974 statement by Dr. Elwood P. Blanchard, a vice president of DuPont, as referred to by Professor Rowland in March 1987: "Back in 1974, an official of the DuPont Company told a Congressional subcommittee that if credible evidence should be developed to show that [CFCs] posed a hazard to human health DuPont would stop manufacturing them. These days, the [CFC] industry appears to have decided that it does not intend to consider any evidence credible as long as there is the slightest doubt about the validity of any part of the ozone-depletion hypothesis." Dr. Blanchard confirmed in 1987 that "no unequivocal trends of ozone depletion have yet been verified." *Ozone Depletion*, *supra* note 2, at 433, 455.

48. See *supra* note 45.

49. WRI 1986, *supra* note 1, at 173.

50. *Id.* at 173-174.

51. WRI 1986, *supra* note 1, at 174. See also *infra* note 52.

52. Projected rates of warming are 10 to 60 times faster than any rates since the last Ice Age. AUDUBON, *supra* note 22, at 195.

53. See *infra* notes 166-69 and accompanying text.

The transportation sector is a primary contributor to CO₂ emissions. The United States is one of the largest producers of carbon dioxide emissions: the average new American car that meets emission standards, if driven ten thousand miles a year, will release its own weight in carbon as carbon dioxide.⁵⁴ Cars with better mileage and fewer emissions are available. Yet, the United States has been hesitant to impose tougher standards that would force the use of such cars⁵⁵ because of the significant economic impact such a policy would have on the automobile industry. Emission-efficient cars would be more expensive and would require extensive research and development, especially with respect to alternative fuels.⁵⁶

Another major area of concern is coal combustion; coal produces about twice the carbon dioxide for the amount of energy as natural gas.⁵⁷ Yet, incentives for the further development of natural gas have been reduced. Dr. Moomaw of the World Resources Institute advocates a return to the mix of coal and natural gas utilized during the oil crisis of 1973.⁵⁸ This policy, combined with efficiency efforts in the automobile industry, would reduce carbon dioxide emissions dramatically, perhaps as much as twenty-five percent in the next twenty years.⁵⁹ Measures controlling emissions in these areas should be combined with efforts to phase out CFCs.⁶⁰

54. *Hearings, supra* note 45, at 143-44 (testimony of Dr. William Moomaw). *See also infra* note 134 and accompanying text.

55. *Id.*

56. Various alternative fuels are available, including ethanol, reformulated gasoline, methanol, compressed natural gas, hydrogen, and electricity. Each fuel has distinct advantages and disadvantages.

The large oil companies and auto manufacturers hope to slow the pace of change and thus far they have been successful in "watering down" proposed legislation in both the House and the Senate. *Houston Chron.*, May 21, 1990 at 1B, col. 2, and at 2B, cols. 1-4. "Clean fuel" has been defined in the U.S. as one that emits 40% fewer hydrocarbons and 50% fewer toxic pollutants such as benzene. An ultra-clean car would cut hydrocarbons by 80% and air toxins by 90%. *Houston Chron.*, Jan. 12, 1990, at 1B, col. 6 and at 4B, cols. 5-6.

It does seem clear measures will at least be taken to require nozzles on gas pumps in the most polluted cities, as well as to impose tailgate emission standards on the cars. *Houston Chron.*, June 10, 1990, at 15A, col. 2.

By contrast, in 1985, the European Community enacted a directive implementing auto exhaust emissions standards designed to reduce sulphur and nitrogen oxide emissions by 60%. WRI 1986, *supra* note 2, at 177. These reductions will be accomplished through a program phasing in catalytic converters on vehicles and increasing use of unleaded petrol through 1993. *Id.*

57. *Hearings, supra* notes 45 and 54, at 144 (testimony of Dr. Moomaw).

58. *Id.*

59. *Id.* at 183-84.

60. *Id.* at 186.

The Natural Resources Defense Council (NRDC) in the United States recently released a study based on data from the Oak Ridge National Laboratory. The study showed that the United States had the dubious honor of leading the world in CO₂ emissions in 1988 with 4.8 billion metric tons. The state of Texas alone produced 553 million pounds, which tied it with Great Britain and ranked it seventh in the world. Other countries also released extremely high levels of carbon dioxide. The USSR released 3.9 billion tons, China 2.1 billion tons, Japan 950 million tons, Germany 650 million tons, and India 580 million tons.⁶¹

Production of CFC gases for non-propellant uses has steadily increased.⁶² If this is allowed to continue, CFCs will be the second largest contributor (after CO₂) to the greenhouse effect during the first half of the Twenty-First Century. Methane levels have also increased rapidly during the last twenty years, at a rate of one to two percent per year. Nitrous oxide emission levels increase less rapidly, but the nitrous oxide already in the atmosphere has a life expectancy of approximately 170 years, during which time chemical reactions will continue. In other words, even if emission rates were held constant, atmospheric concentrations would continue to increase for several decades. A recent study suggests a twenty to twenty-five percent increase in atmosphere concentrations of nitrous oxide by 2030.⁶³

However, there are other sources of CO₂ emissions. The World Resources Institute released data in June 1990 that the destruction of the world's tropical forests was occurring at a rate fifty percent faster than previously estimated.⁶⁴ Tree-burning accounts for an estimated thirty percent of world-wide CO₂ emissions.⁶⁵ The potential for global warming is increasing because of these escalating emissions.

Several global circulation models (GCMs) predicting the effects of global warming have been developed.⁶⁶ The models attempt to link

61. Houston Chron., July 27, 1990, at 1A, cols. 5-6.

62. WRI 1986, *supra* note 1, at 175. CFC levels have continued to rise at alarming rates, even though the Environmental Protection Agency and the Food and Drug Administration in the United States imposed a ban on manufacture and use of CFCs as aerosol spray propellants in 1978. 15 U.S.C. § 2601 *et seq.* (1988), 40 C.F.R. § 762 (1988). Unilateral action on only one front, aerosols, is inadequate.

63. WRI 1986, *supra* note 1, at 176.

64. Houston Chron., June 8, 1990, at 2A, col. 5, reported the findings of a coordinated study by the World Resources Institute, the United Nations Environment Program, and the United Nations Development Program.

65. *Id.* at 2A, col. 6. This study indicated Brazil's losses alone were between 10 million and 20 million acres within the Amazon, and 2.5 million acres outside the Amazon.

66. Frequently referenced models include those run by the National Center for Atmospheric

atmosphere-ocean and atmosphere-biosphere processes. These models assume a doubling of CO₂ from pre-industrial levels and predict global warming from 2.5 degrees Centigrade to 5.5 degrees Centigrade.⁶⁷

All models predict greater changes at high latitudes.⁶⁸ Specific regional projections are difficult because of the thermal inertia of the earth's oceans, causing atmospheric warming to lag from between ten to one hundred years.⁶⁹ Clouds are also a complicating factor. The present models can assess cloud cover or humidity on a global scale, but cannot forecast local variations.⁷⁰ Equatorial temperatures will likely increase more than other worldwide temperatures, but average polar temperatures

Research (NCAR), NOAA's Geophysical Fluid Dynamics Laboratory (GFDL), NASA's Goddard Institute for Space Research (GISS), and Oregon State University. AUDUBON, *supra* note 22, at 187.

67. Major studies also center on assembling a complete record of climatic conditions over the past 200,000 years, spanning two ice ages and two warm or "interglacial" periods. Scientists are engaged in taking ice cores from Greenland and East Antarctica, looking for clues that will assist in predicting global warming. Scientists in Greenland have bored a hole that will eventually provide a core of ice 10,000 feet long. Oxygen isotopes and changes in electrical conductivity show evidence of past surface temperatures and acidity variations. Wind and air circulation patterns can be determined, and measurements can also be taken of greenhouse gases such as methane and carbon dioxide. Scientific coordinator Paul Mayewski at the Greenland bore hole (GISP2) states that information disclosed thus far confirms human have made major changes in the climate. However, the exact mechanisms of greenhouse warming are not yet well understood. Houston Chron., Feb. 26, 1990, at 6B and 7B col. 2-4.

68. AUDUBON, *supra* note 22, at 188.

69. Stephen Schneider, Senior Scientist at NCAR in Boulder, Colorado explains:

[T]he oceans heat up differentially. The "mixed layer" of the ocean (the layer stirred up by wind turbulence), which is only about 50 meters thick in the tropics, takes about ten years to absorb three-fourths of all the heating it is going to absorb. That means the tropics, which "in equilibrium" don't warm up as much as the poles in our climate models, actually *start* warming up faster than the poles. The reason is that at the poles, because the water is cold and salty, it sinks right to the bottom. You don't have a thin mixed layer; you've got a deep, deep layer and it can take a century to warm up. However, in the long run, the poles will warm up more than the equatorial waters, because the ice melts and that gives you a so-called amplifying "feed-back" effect—that is, as the snow and ice decrease, the darker earth's surface at the poles absorbs more energy, thus creating a larger final warming. But in the short run, it's the reverse.

Moreover, it isn't temperature change overall that is so important to the local climate; it is temperature change from place to place. Different gradients of change cause differential pressure patterns. This leads to differential wind patterns, which leads to surprises.

Fleming & Lock, *Interview: Stephen Schneider*, 4 NATURAL RESOURCES & ENVIRONMENT 26-27 (1989) [hereinafter *Schneider*].

70. The models are only partially validated. One method to remedy the problem is application of a meso-scale high-resolution model in the GCM at one grid point. NCAR is testing this application for the Department of Energy (DOE) at Yucca Mountain in Nevada. Accuracy is limited. The alternative, to run an entire global model at higher resolution, would cost an estimated fifty million a year if done at two climate centers. *Id.* at 27-28.

are likely to rise by two to three times the average global increase.⁷¹ The resulting melting of ice and the thermal expansion of the oceans' upper layer will affect sea level, although estimates of the extent of the rise vary greatly.⁷² It is clear that major coastal areas would be greatly affected. Many areas around the world would be inundated by the rise in sea level, including parts of East Texas, Louisiana, and Florida in the United States. A " . . . 0.3-meter rise would erode most sandy beaches along the U.S. Atlantic and Gulf coasts 30 meters inland."⁷³ Along with this rise comes the threatened contamination of groundwater by salt water, an additional major concern.⁷⁴

Agriculture is acutely sensitive to climate; therefore, growing seasons would be affected. There is evidence that mid-latitude, mid-continental drought possibilities would increase.⁷⁵ Some estimates predict the United States Corn Belt production could expect a twenty percent reduction in yields with an increase in temperature of just two degrees Centigrade; a ten to fifteen percent reduction in yields would result if precipitation decreased by ten percent.

71. WRI 1986, *supra* note 1, at 177.

72. By 2100, sea levels are expected to rise from one to three meters. AUDUBON, *supra* note 22, at 191, citing Peltier, *Global Sea Level and Earth Rotation*, 240 SCIENCE 895-901 (1988). The rise would be due mostly to thermal expansion of water, but melting of the poles and glaciers would also play an important role.

73. *Id.* With slow sea level rise, coastal wetlands respond over the long-term by migrating upward and landward. Many existing wetlands will be unable to migrate at the rate of predicted sea level rise, and will be partially or totally converted to sea water. The United States is expected to lose 25%-50% of its coastal wetlands by 2100. Current beach erosion of two to five feet per year is expected to double or quadruple because of sea level rise. AUDUBON, *supra* note 22, at 205.

74. Rising sea levels will also force disappearance of salt-intolerant species and reduce freshwater coastal wetlands. Changes in temperature may alter near shore circulation and upwelling patterns, having a negative effect on species dependent upon freshwater and upon fisheries. *Id.* at 205-06.

75. Greenhouse warming will cause major crop growing areas to migrate. Under conditions of increased CO₂, photosynthetic rates of C3 plants (such as wheat and soybeans) increase considerably. This effect is much less pronounced in C4 plants (sugar cane, corn, and tropical grasses). In contrast, C4 plants become more efficient in water usage when exposed to elevated levels of CO₂, but C3 plants become less efficient if CO₂ levels become too high. AUDUBON, *supra* note 22, at 200-01.

Nonagricultural plant life will also be affected. Southern biological forms will migrate northward in the northern hemisphere, and withdraw along their southern edge. The United States may see the boreal forest of Northern Minnesota replaced by hardwoods, and loblolly pines in the South shifting several hundred miles northward by 2050. *Id.* at 199.

Movement of plant life will not only be northward. At a recent Texas Urban Forestry Conference, Professor North of the Texas A & M Climate System Research Program, projected an average increase in Texas temperatures of five degrees Fahrenheit by 2050, resulting in an eastward shift of the Texas tree line. Houston Chron., May 11, 1990, at 1A, cols. 4-6.

Agriculture in developing countries would also be affected by a changing climate. An average global warming of 4 degrees Centigrade could result in a 2.5 to 4 degree Centigrade increase in temperatures between 35 degrees North latitude and 20 degrees South latitude. These increases would result in reductions in crop yields. In turn, this would increase pressure to expand areas of cultivation, increasing burnoff of forests, and again increasing introduction of CO₂ into the atmosphere.⁷⁶

Long-range effects are complex. As one example, stream acidity in the Rocky Mountains is dependent upon the rate at which spring snow melt occurs. If the spring snows melt quickly, then there is more runoff and consequently less absorption by the soil. Thus, the quicker the snowmelt, the more acidic the runoff and vice-versa. This, in turn, affects the life cycles of numerous wildlife. The timing of animal migrations could be disrupted. Inability to respond effectively to these disruptions could mean extinction.⁷⁷

Additional effects of global warming can be seen in weather patterns, including the increased severity and frequency of storms. It has been estimated that the destructive potential of hurricanes will increase by forty to fifty percent with a doubling of CO₂. Warming will also cause a northward shift in the track of continental storms.⁷⁸

It is clear that the consequences of mankind's introduction of chemicals into the atmosphere are inevitable. The challenges are to minimize the impact by slowing the process, and perhaps reversing some of the trends. Major issues of debate center on what actions need to be taken, how quickly those actions should be taken, and how pervasive the response should be.⁷⁹ Perhaps the greatest contribution of all the studies initiated since the early 1970s has been the realization that all nations are affected by this atmospheric crisis; therefore, all nations must respond.⁸⁰

76. WRI 1986, *supra* note 1, at 177.

77. AUDUBON, *supra* note 22, at 202-04.

78. *Id.* at 191.

79. Stephen Schneider of NCAR remains optimistic that affirmative action taken now can result in a two degree warming instead of a six degree warming, which would take place in one hundred years instead of fifty years. This slower, less extreme change would afford all nations, as well as plant and animal life, a better opportunity to adapt. *Schneider, supra* note 69, at 56.

80. Even environmental degradation in Third World countries has transnational repercussions. Accelerating loss of tropical rain forests is likely to upset global rainfall and will result in a significant loss of biological diversity with attendant environmental, scientific, and medical implications. The problem calls for "concerted international efforts and refined international rules of conduct that give expression to the fact that all nations have a stake in maintaining ecological stability in less developed countries." Handl, *Environmental Protection and Development in Third World Countries: Common Destiny—Common Responsibility*, 20 N.Y.U.J. INT'L L. & POL. 603, 605, 610 (1988).

III. TRADITIONAL TREATMENT OF AIR POLLUTION AS AN ISSUE WITHIN OR BETWEEN SOVEREIGN STATES

A. *The "Good Neighbor" Policy*

The earliest cases dealing with pollution problems handled the matter as an internal or transboundary dispute. The landmark Trail Smelter Case⁸¹ involved a smelter established in British Columbia in 1896 which caused significant pollution in Washington State between 1925 and 1931. Several individual claims were settled. However, in 1927 private remedies were deemed inadequate and unsatisfactory because the smelter continued to operate, and pollution continued to occur.

To solve such on-going problems, the United States in 1927 proposed establishment of an International Joint Commission. A convention was finally signed in 1935 which established a tribunal to determine whether the Trail Smelter should be required to stop future acts of pollution. If so, the tribunal was to determine what measures should be taken to achieve this objective, and what damages should be paid for past pollution. In 1941, the final judgment formulated the "good neighbor" principle⁸²:

[U]nder the principles of international law, as well as of the law of the United States, no 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.⁸³

B. *Problems with Resolution of Transboundary Harm*

Direct resolution of transboundary harm still remains a viable option when both the victim and the polluter can be identified. However, multiple polluters are frequently involved over extended periods of time,

81. See *supra* note 12 and accompanying text.

82. Customary international law becomes binding when it is generally accepted by the international community and is accompanied by corresponding states' practice. In the Trail Smelter case, there was no conflict between international law and the United States law. I. VAN LIER, *supra* note 8, at 104-08. Another example in this context is the declaration of the United Nations Conference on the Human Environment, adopted in Stockholm on June 16, 1972. New Zealand and Australia relied on this declaration as customary law (reflective of the world community) in the Nuclear Test Case. *Id.* at 97; 1974 I.C.J. 252 (1974).

83. I. VAN LIER, *supra* note 8, at 108, citing Trail Smelter Arbitration (U.S. v. Can.), 3 R. INT'L ARB. AWARDS 1963-65 (1949).

making source identification very difficult.⁸⁴ A good example of identification problems occurs with acid rain. Wind formations can distribute precipitation in complex patterns over long distances.⁸⁵ Therefore, it is often impossible to say that a particular source was the place of origin, although that source could have been a contributing factor.⁸⁶ Recent studies in the Federal Republic of Germany (FRG) underscore this point. The FRG estimates that:

[Its country] is responsible for 124,000 metric tons of sulfur deposited in upwind France each year. France reciprocates by sending an estimated 167,000 metric tons across the FRG border where it contributes to a grand total of 760,000 metric tons dumped annually on the FRG.⁸⁷

In attempting to identify harmful sources, fault and causation are not identified only by active negligence or malice. Fault can also include passive failure to comply with an obligation, or an error of judgment, even if it is a bona fide error.⁸⁸ It may therefore be possible to proceed against a neighboring state even if specific sources of pollution cannot be identified. However, this will not assist in untangling the complex exchange of pollutants shown in the FRG example above.

Actions may be brought based on the common law. For example, actions may be based in negligence, but it is often difficult to determine what standards a prudent operator should follow, not to mention problems with establishing causation and foreseeability. Nuisance provides another alternative basis for action. It focuses on a substantial and unreasonable interference with another's use and enjoyment of property. Thus, the effect, rather than the cause, of the pollution is under scrutiny. It may be as difficult, however, to identify these effects as to identify the victims. Damages may be spread over large areas and not readily apparent.

84. I. VAN LIER, *supra* note 8, at 88.

85. "The acid rain in Scandinavia for instance, is caused by emissions in Great Britain, Germany and France." *Id.* at 40-41.

86. *Id.* at 42. The source of acid rain between the United States and Canada has long been in dispute. Experts on both sides of the border now agree that more than 50% of the acid rain in eastern Canada originates in the United States. *Houston Chron.*, July 9, 1990, at 4A, col. 3.

Identifying the particular company or industry responsible for a particular percent of the pollution is not always feasible. In Houston, Texas, recent proposals to track air pollution to its source will require expenditures of \$500,000. While this proposed complex monitoring program may track sources of major toxic pollutants, it may not be able to establish exact liability. However, the monitoring system will make measurement of pollutants emitted from the petrochemical complex a public rather than a "private and confidential" program. *Houston Chron.*, June 9, 1990, at 36A, cols. 3-6.

87. WRI 1986, *supra* note 1, at 168.

88. B. CHENG, *supra* note 5, at 225-26.

International standards require proof of injuries, as well as the cause and effect relationship of the polluting activity, with clear and convincing evidence.⁸⁹ This may be possible if damage is only to agriculture or horticulture, but it becomes increasingly difficult when looking to the impairment of human health, or the conditions of buildings.⁹⁰

C. *Direct Resolution by the Victim*

If the individual brings his own claim in his own country, effective results are unlikely because that tribunal may not be competent to rule on problems originating in another country. The polluter may not willingly appear, and it may be difficult to compel appearance.⁹¹ What is more, the type of remedy sought is a factor. For example, injunctions cannot be granted by a court outside the polluter's country.⁹² It may indeed be easier to determine damages, collect evidence, and obtain a judgment in the national's home state,⁹³ but enforcing even a money judgment in the polluter's state remains a problem.

Proceeding with a suit in a foreign country can also be difficult as non-residents generally have no standing to bring suit.⁹⁴ Other problems include unfamiliar languages, different legal systems, the need to post security bonds, and the fact that the foreign victim would not be on equal footing with the state's national.⁹⁵

D. *Action of the State on Behalf of a Victim*

A victim of air pollution has the choice of initiating a case in his own country or in the polluter's country. If he can obtain the diplomatic support of his government, his case can proceed at the international level against the country in which the pollution originated.⁹⁶ The idea is that by an injury to a national, the government has suffered an indirect injury. Claims by the state based upon interests of a national generally result in pecuniary compensation.⁹⁷

89. A.C. KISS, *supra* note 10, at 18-19.

90. *Id.*

91. A.C. KISS, *supra* note 10, at 47. Compelling appearance of a defendant polluter requires a high degree of judicial cooperation.

92. I. VAN LIER, *supra* note 8, at 90.

93. *Id.* at 89.

94. *Id.* at 88. Denmark, Finland, Norway, and Sweden have entered a Nordic Convention on the Protection of the Environment which gives any resident standing in each of the other countries in administrative procedures.

95. A.C. KISS, *supra* note 10, at 47.

96. A.C. KISS, *supra* note 10, at 47.

97. I. BROWNLIE, *supra* note 3, at 404-05.

This diplomatic protection is subject to two conditions: first, the protected individual (the victim) must be a national of the country taking up his claim at the time of injury and at the time the case is initiated; second, in some cases the victim must have exhausted all local remedies.⁹⁸ If the offending act is a breach of international agreement or customary law, and not a breach of local law, local remedies need not first be exhausted. If the act is a breach of local law and international agreement or customary law, the local remedies rule applies in its procedural rather than its substantive essence.⁹⁹ If the act is a breach of local law only, then only conduct within the forum state can create responsibility.

The basis for the local remedies rule is that:

[A]n individual who chooses to be subject to the jurisdiction of a foreign state should first give that state an opportunity to redress the unlawful situation by its own means, within the framework of its own domestic legal system. In the case of transfrontier pollution, the victim has not chosen to be subject to the jurisdiction of the state from whose territory the pollution originates.¹⁰⁰

Where the victim's only connection with the foreign state is the act causing the injury, exhaustion of local remedies is not necessary. Indeed, such a requirement would conflict with international law permitting the plaintiff-victim a choice of forum.¹⁰¹

E. Action of the State on its Own Behalf

In addition to bringing an action on behalf of a national based upon a theory of indirect injury, a state may bring an action on its own behalf, complaining of direct injury. If a claim taken up by the state is based upon an interest of the state itself, it may lead to a request for a declaration of responsibility or a decision interpreting or applying a treaty.¹⁰²

Sometimes a state may wish to bring a claim on behalf of non-nationals within its boundaries, but it is unclear whether a state may do so. This should be possible because the state must be able to make its territory attractive to foreigners, offer them protection, and meet interna-

98. I. VAN LIER, *supra* note 8, at 91.

99. I. BROWNLIE, *supra* note 3, at 403-04.

100. I. VAN LIER, *supra* note 8, at 93.

101. *Id.*

102. I. BROWNLIE, *supra* note 3, at 404-05.

tional obligations.¹⁰³ A.C. Kiss argues that a state may bring this action, not on the basis of diplomatic protection, but rather on a theory of direct injury.¹⁰⁴

The state is often caught in a paradox. On one hand, the state has responsibility for the acts of its citizens if they knew or should have known that their acts were harmful to the interests of another state. On the other hand, the state also has a legitimate interest in protecting its own citizens from foreign governmental interference. This is most evident in problems involving multinational corporations. However, the question arises whether the "injurious activity must not only be located in the territory of the state of origin, but must also be under the effective control . . . of that state in order for that state to be liable."¹⁰⁵

This problem became very apparent after the 1984 chemical explosion in Bhopal, India. One member of the International Law Commission (ILC) suggested that the state in which the multinational corporation (MNC) is incorporated or headquartered (in this case the United States) be responsible for injuries caused by hazardous substances or technologies exported to other countries. The rationale is that the home state has the best opportunity to know risks and take steps to negate or warn recipient countries of such risks.¹⁰⁶ This kind of liability would obligate home states to determine which technologies and substances could be exported to developing countries. However, this approach would generate unwelcome paternalistic overtones, as well as shift jobs and wealth away from the Third World and back to the industrialized countries.

The ILC favors a private law approach in these situations even though private mechanisms of resolution may be very slow. If judgment can be obtained in the polluter's own country, enforcement will be easier.¹⁰⁷ However, additional complications may arise if the polluter is a state organ because it may be entitled to jurisdictional immunity in a foreign court.¹⁰⁸ A final complicating factor is the conflict of laws issue: will the laws of the jurisdiction where the wrongful act occurred control, or the laws where the injury was sustained? Different jurisdictions vary in defining the polluter's status if the polluter has been acting

103. I. VAN LIER, *supra* note 8, at 93.

104. *Id.* at 92, citing Kiss, *Problèmes Juridiques de la Pollution de L'Air*, *ACADÉMIE DE DROIT INTERNATIONAL DE LA HAYE, COLLOQUE 1973 - LA PROTECTION DE L'ENVIRONNEMENT ET LE DROIT INTERNATIONAL* 165-66 (1975).

105. McCaffrey, *The Work of the International Law Commission Relating to Transfrontier Environmental Harm*, 20 *N.Y.U.J. INT'L L. & POL.* 715, 719 (1988).

106. *Id.* at 723.

107. I. VAN LIER, *supra* note 8, at 89.

108. *Id.* at 88.

legally and was properly licensed. Types of available remedies and applicable standards also vary. Thus, the choice of tribunal can have a major impact on final resolution of the matter.¹⁰⁹

F. *The Need to Move Beyond Traditional Approaches*

It is increasingly apparent that traditional notions of absolute state sovereignty in cases of transboundary environmental injury are impractical.¹¹⁰ If there is to be a principle that a state will be liable for pollution originating in its own territory which causes damage beyond its frontiers, it needs to be more clearly stated.¹¹¹ Most significantly, rules addressing international liability and compensation for damages do not address the pressing issue of prevention.¹¹²

Many of these problems of enforcement, standing, immunity, or conflict of laws can generally be resolved only by special agreements between neighboring countries. A.C. Kiss suggests that international joint commissions be established that are empowered to determine the liability of polluters and to compensate injured parties.¹¹³ He points to the International Joint Commission between the United States and Canada, operating since 1966,¹¹⁴ which allows mutual jurisdiction between the United States and Canada. For example, the United States can obtain jurisdiction over a polluter in Canada even though the injury (the pollution) is the only contact the polluter has with the United States. The Nordic Convention in Scandinavia is another example, granting standing to residents of any of the participating countries.¹¹⁵ Additionally, European civil law, which is based on tort principles, has been interpreted to give the injured party a choice of jurisdiction.¹¹⁶ Outside the European

109. *Id.* at 90. For example, the FRG applies laws most favorable to the plaintiff or victim: a polluter bound by relatively moderate national standards may be "tested" by stricter standards of a receiving country.

110. *Ozone Depletion*, *supra* note 2, at 441.

111. A.C. Kiss, *supra* note 10, at 47.

112. *Id.* at 45.

113. *See supra* note 12.

114. A.C. Kiss, *supra* note 10, at 46. The proposed accord between Canada and the United States over acid rain is another example of explicitly setting forth dispute resolution procedures. *Houston Chron.*, July 9, 1990, at 4A, col. 3.

115. Nordic Convention on the Protection of the Environment, Feb. 19, 1979, *reprinted in* 13 I.L.M. 591 (1974).

116. The Common Market Convention on the Jurisdiction of Courts and the Enforcement of Judgements in Civil and Commercial Matters, Sept. 27, 1968, *reprinted in* 8 I.L.M. 229 (1969) provides that tort actions may be brought at the place "where the harmful event occurred." The EEC Court of Justice has interpreted this to include both the place of the act and the place of the injury, so that the plaintiff may choose his jurisdiction. (*Reinwater Foundation Case*). I. VAN LIER, *supra* note 8, at 89.

Economic Community (EEC), common law dictates that jurisdiction is determined by the location of the property.¹¹⁷ It is apparent that if pollution issues are to be addressed effectively, special agreements are necessary. Various international organizations have been created to facilitate dealings between nation states, addressing issues of jurisdiction, standards, arbitration, and standing.

IV. DEVELOPMENT OF INTERNATIONAL LEGAL STRUCTURES OR AGREEMENTS TO CONCEIVE AND IMPLEMENT A GLOBAL SOLUTION TO THE GREENHOUSE EFFECT

In 1972 at the time of the United Nations Conference on the Human Environment in Stockholm, Sweden (hereinafter Stockholm Human Environment Conference), twenty-five countries (eleven in the developing world) had agencies specifically designed to address environmental problems. Today, over one hundred and forty countries have such agencies. However, integration and implementation of policy and effectiveness of controls are separate and difficult issues.¹¹⁸

The United Nations Convention on Long-Range Transboundary Air Pollution was held at Geneva, Switzerland, November 13, 1979 (hereinafter the Geneva Air Pollution Convention). This Convention addressed the problem of long-range pollution by advocating not only further studies but also affirmative action. Article Six of the Geneva Air Pollution Convention set forth the intent of each contracting party; specifically, to

develop the best policies and strategies including air quality management systems and, as part of them, control measures compatible with balanced development, in particular by using the best available technology which is economically feasible and low- and non-waste technology.¹¹⁹

The Geneva Air Pollution Convention was developed through the framework of the Economic Commission for Europe. One of the signors was the European Economic Community, and the primary focus of the agreement was the European problem of acid rain.¹²⁰ Parties pledged cooperation in research and development of technology, and exchange of information.¹²¹

117. This includes common law jurisdictions outside the EEC, the United States, and Canada.

I. VAN LIER, *supra* note 8, at 90.

118. WRI 1986, *supra* note 1, at 191.

119. United Nations Convention on Long-Range Transboundary Air Pollution, Nov. 13, 1979, reprinted in 18 I.L.M. 1442, 1444 (1979).

120. *Id.*, arts. 7 and 8.

121. *Id.*, art. 8(f) included a search for information correlating measurable damage with long-

The Stockholm Human Environment Conference and the Geneva Air Pollution Convention focused attention on the need to rationally manage the environment, to pursue economic development and technological progress in a manner consistent with environmental protection, and particularly to realize that "damage to the environment is best avoided by preventive measures."¹²² Interestingly enough, a Protocol to the Geneva Air Pollution Convention was promulgated September 28, 1984. This Protocol provided financing for monitoring and evaluation programs set out by the Convention.¹²³ The Protocol set mandatory and voluntary monetary contributions from signatories, and included non-European signatories as well as Eastern Bloc nations. Access to the data was an incentive to participate.¹²⁴ On March 22, 1985, the first worldwide legal instrument for the protection of the atmosphere was produced: The Vienna Convention for the Protection of the Ozone Layer (hereinafter Vienna Ozone Convention).¹²⁵ Systematic observations and further research were to be directed at the physical and chemical processes affecting the ozone layer, human health, climatic effects (including the development of theoretical models, lab studies, and field measurements), the effects of changes in UV-B radiation on natural and synthetic materials, alternative chemicals and technologies, and related socio-economic matters.¹²⁶ Chemicals specifically listed to be studied included carbon monoxide, carbon dioxide, methane, non-methane hydrocarbon species, nitrous oxide, nitrogen oxides, chlorine and bromine substances (halogenated alkanes), hydrogen, and water.¹²⁷

The Vienna Ozone Convention was a major breakthrough in focusing world-wide attention on the fragility of the ozone layer, an issue of global impact. Ensuing studies also have been instrumental in convincing nonindustrial, developing nations that concerted efforts to preserve the environment are necessary to sustain their economies.¹²⁸

range transboundary air pollution, but a footnote specifically stated that the Convention contained no rule regarding state liability for any damage. 18 I.L.M. 1442, 1445 (1979).

122. Declaration on Low- and Non-Waste Technology and Re-utilization and Recycling of Wastes, Resolution on Long-Range Transboundary Air Pollution, Nov. 13, 1979, Geneva, *reprinted in* 18 I.L.M. 1451 (1979).

123. Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution, On Financing the Monitoring and Evaluation of Air Pollutants in Europe, Sept. 18, 1984, 24 I.L.M. 484 (1985). The Eastern Bloc nations and the Soviet Union had boycotted the 1972 Conference in Stockholm. *See supra* note 2.

124. *Id.*

125. Vienna Convention for the Protection of the Ozone Layer, March 22, 1985, *reprinted in* 26 I.L.M. 1529 (1987).

126. *Id.*, art. 3, § 1, 26 I.L.M. 1530 (1987).

127. Annex I to the Vienna Convention, 26 I.L.M. 1538-39 (1987).

128. No comprehensive study of Third World attitudes toward conservation has been made,

In October of 1985, a World Resource Institute conference was held in Villach, Austria, to review data on greenhouse gases, climatic change, and associated impacts.¹²⁹ Statistics closely linked changes in the earth's ozone layer, the greenhouse effect, and other environmental threats to man's activities. The conference concluded:

- (1) Escalating amounts of dangerous trace gases such as carbon dioxide, nitrous oxide, methane, chlorofluorocarbons (CFCs), and ozone are being found in the troposphere.
- (2) The dangerous effects of greenhouse gases other than CO₂ on the Earth's climate are nearly as significant as the effects of CO₂. By the year 2030, CO₂ and other greenhouse gases could double pre-industrial CO₂ levels.
- (3) The most advanced general circulation experiments show increases of the mean global equilibrium surface temperature of 1.5-4.5 degrees celsius.
- (4) Although general circulation models are not completely accurate, they have shown that warming may be greater in higher altitudes, especially during late autumn and winter. Annual runoff may increase, causing drought conditions during the summer months. In tropical regions, temperatures will not be as affected, but environmental effects could be equally as devastating.
- (5) Global warming of 1.5-4.5 degrees would cause sea level to rise 10-140 centimeters.
- (6) The general circulation models' projected changes to the environment would have substantial and possibly irreversible effects if current trends are not slowed or stopped altogether.¹³⁰

but national surveys indicate potential for a growing conservation ethic: a 1983 survey of school children in Tanzania indicated 45% agreed that if food were scarce, national parks should be used for farming, but 39% disagreed. In Rwanda, the proportion of farmers who saw some use in conserving the forest rose from 49% to 81%, and the proportion who thought the protected area should be converted to agriculture fell from 51% to 18% (result of a national conservation awareness campaign in the 1980's). "Whatever the conservation attitudes of the Third World public, the reality of the international debt crisis is forcing many governments to draw down their natural resource bases rapidly." WRI 1988-89, *supra* note 1, at 100.

129. WRI 1986, *supra* note 1, at 175.

130. WRI 1986, *supra* note 1, at 175, citing UNITED NATIONS ENVIRONMENT PROGRAM/WORLD METEOROLOGICAL ORGANIZATION (WMO)/INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS, AN ASSESSMENT OF THE ROLE OF CARBON DIOXIDE AND OF OTHER GREENHOUSE GASES IN CLIMATE VARIATIONS AND ASSOCIATED IMPACTS (1985) (WMO, Geneva, Switzerland).

The Villach Conference stressed the need for development of more sophisticated general circulation models to better predict the effects of climate changes.¹³¹ Areas with known regional vulnerability included the Amazon Basin, the Indian subcontinent, Europe, the Arctic, the Zambezi Basin, and the North American Great Lakes.¹³²

The "Bellagio Report,"¹³³ a major product of the studies generated by the Villach Conference, urges immediate action to preserve the environment. Findings included:

- (1) The Earth's mean temperature will probably rise and there is no known limit to this rise so long as greenhouse gases continue to multiply in the atmosphere.
- (2) Considering the oceans' slow heating rate, it may take up to forty years for any significant change in temperature to appear. However, this would be effectively irreversible since greenhouse gases are long lived.
- (3) Slowing the warming trends and ultimately stabilizing the atmosphere will require a sixty percent reduction in fossil fuel emissions and similar reductions in other greenhouse gases from current levels.¹³⁴

Dr. Oppenheimer of the Environmental Defense Fund stresses the development of national energy policies and research and development of non-fossil fuel energy systems. He urges use of low-CO₂ fuels, control of nitrous oxides, methane and tropospheric ozone emissions, and funding to develop technologies which do not rely on ozone-damaging chemicals.¹³⁵

Indeed, one of the most promising international responses to the growing problem of global warming has been adoption of the Montreal Protocol on Substances that Deplete the Ozone Layer, opened for signature September 16, 1987.¹³⁶ This Protocol represents the first time

131. See *supra* note 66 for a listing of frequently referenced global climate models. See also *supra* note 45.

132. See *supra* note 130.

133. WORLD METEOROLOGICAL ORGANIZATION (WMO) AND THE UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP), DEVELOPING POLICIES FOR RESPONDING TO CLIMATIC CHANGE (1987) [hereinafter BELLAGIO REPORT]. Major participants included the Environmental Defense Fund, the Beijer Institute of the Royal Swedish Academy, and the Woods Hole Research Center. The project was a direct outcome of the Villach Conference and meetings in Villach, Austria and Bellagio, Italy in 1987. *Hearings, supra* note 45, at 84 (statement of Dr. Michael Oppenheimer of the Environmental Defense Fund).

134. *Id.* at 86-88.

135. *Id.* at 88-89.

136. Montreal Protocol on Substances that Deplete the Ozone Layer, Sept. 16, 1987, *reprinted in* 26 I.L.M. 1550 (1987) [hereinafter Protocol].

an international agreement has imposed specific obligations on its signatories. It limits the consumption and production of chemicals that are harmful to the environment. The Protocol is directed to CFCs and halogens, and creates a model for future agreements concerning other harmful chemicals. It calls for a freeze in consumption by 1989, and for progressive reductions of twenty percent by 1994 with a thirty-percent reduction by 1999.¹³⁷ Developing nations will have a ten year grace period unless consumption rises above certain levels.¹³⁸

The Protocol also regulates exports and imports. For example, imports of CFCs and halons from nonparties are banned after 1990.¹³⁹ Beginning in 1993, developing nations will not be permitted to export CFCs or halons to nonparties of the Protocol. All parties to the Protocol are to facilitate development and use of safe alternatives to the use of ozone-damaging chemicals and technologies.

The Protocol is a landmark document in that for the first time nations have agreed on preventive environmental controls, taking action before actual damages to human health and ecology have accrued. It has set a precedent for future agreements, because it is based on modern scientific techniques, computer modeling, satellite measurements, and atmospheric chemical theory." It is designed to provide clear incentives to industry to develop substitute products and technologies to reduce emissions of ozone-destroying chemicals."¹⁴⁰

Studies encouraged reconvening the Montreal Protocol since evidence indicated its cutbacks were inadequate. Bowing to this pressure, the Protocol was amended on June 29, 1990. The amendment accelerated the freeze in consumption and production by calling for industrialized nations to completely phase out use of CFCs by the year 2000. The ten year grace period for developing nations was retained.¹⁴¹

Acceleration of the deadline was made possible for several reasons. First, a study released by the United Nations International Panel on Climate Change (IPCC) lent increased credibility to projections that global mean temperatures are on the rise.¹⁴² Second, the United States

137. *Id.*, art. 2 (Control Measures).

138. *Id.*, art. 5. Low-consuming countries are thus provided an incentive to participate. The Protocol has twin goals of ending ozone degradation and allocating the burden fairly. Tripp, *The UNEP Montreal Protocol: Industrialized and Developing Countries Sharing the Responsibility for Protecting the Stratospheric Ozone Layer*, 20 N.Y.U.J. INT'L L. 742-43, 733 (1988).

139. *Id.*, art. 4.

140. Comment, *Thinning Air, Better Beware: Chlorofluorocarbons and the Ozone Layer*, 6 DICK. L. REV. 87 (1987) (foreword by Richard E. Benedick).

141. Wall St. J., June 29, 1990, at A7, col. 1.

142. Houston Chron., July 8, 1990, at 30S1, col. 1. The 170 scientists on the committee predicted temperature rises of 5 degrees to 9 degrees Fahrenheit over the next century.

reversed its policy and agreed to support a special international fund to provide financial and technological assistance to developing nations. This fund will enable the countries to shift to chemicals that are safer to the atmosphere.¹⁴³ The fund will total from \$150 to \$250 million.¹⁴⁴ Third, recent technological developments have made chemical alternatives available. A new market for hydroflouorocarbons (HFC 134a) can be developed replacing many uses for CFCs.¹⁴⁵ Other ozone-friendly chemicals include terpenes, which are natural solvents that can be used in the manufacture of circuit boards.¹⁴⁶ Industry continues to explore replacements in various other compounds which have traditionally used CFCs.¹⁴⁷

Unfortunately, even as amended, the Protocol provides no standards or penalties for non-compliance.¹⁴⁸ Although nations must not use their territory in ways that damage other nations, this is difficult to enforce since the causes of ozone depletion are not well known. Additionally, no mechanisms exist for issuing injunctions to halt infractions. Until penalties and sanctions are specifically provided, the success of the Protocol will depend largely upon voluntary compliance.¹⁴⁹

Third World countries originally perceived efforts to limit environmentally dangerous chemicals as part of a conspiracy to hinder their development. These perceptions, fortunately, have changed. Many developing nations now recognize they are paying significant prices in plant and animal damage, as well as in depletion of natural resources; ozone-damaging chemicals are perpetuating a cycle of poverty.¹⁵⁰ Major pro-

143. Wall St. J., June 18, 1990, at A7A, col. 4.

144. Houston Chron., June 16, 1990, at 17A, col. 1.

145. Wall St. J., June 29, 1990, at A6C, col. 1.

146. Wall St. J., May 18, 1990, at B1, col. 1.

147. Wall St. J., June 29, 1990, at B1, cols. 3-5 and B5, cols. 5-6. These products include hairsprays, windshield-washer fluid, and paints. Antifreeze and refrigeration compounds remain among the most difficult to replace. *Id.* European companies hope to be able to merge in order to compete with larger U.S. rival companies, including DuPont. Larger companies including DuPont, Hoechst of West Germany, ICF Atochem of France, Allied-Signal, Inc. of New Jersey, and Showa Denko of Japan, are most likely to be able to compete in the market. CFC production, traditionally a simple low-technology business, will be replaced with more costly products requiring more complex production techniques. Wall St. J., June 29, 1990, at A7, cols. 2-3.

148. Protocol, *supra* note 9, art. 8. This Protocol was amended in June 1990, but noncompliance issues still were not addressed. *See supra* note 141.

149. For example, eight years after the EPA imposed its ban on aerosol uses of CFCs, five U.S. companies still sold nearly \$750 million worth of CFC products annually. What is more, the second phase of the EPA response to CFCs was rejected when it became apparent that substitutes for refrigeration and foam plastics would be "too costly and difficult to produce." As a result, industry has made little effort to find or develop alternatives in these areas. *Ozone Depletion*, *supra* note 2, at 433, 437, 454.

150. WRI 1986, *supra* note 1, at 164. *See also supra* notes 28-32 and accompanying text.

jects formerly seen as "progress," including massive water projects, are now seen to cause "massive damage" such as the "irreversible loss of wildlife and genetic diversity, loss of agricultural and forest land by inundation, reduction of site-related fertility, [and] intensified erosion . . ." of the land.¹⁵¹

Varying national economic levels and needs make it difficult to develop plans calling for coordinated efforts between industrialized and developing nations.¹⁵² Nevertheless, progress continues. The 1990 Houston Economic Summit Communique welcomed reassessment of the Montreal Protocol by India and China, now that a financial mechanism has been created to assist developing nations in moving away from the use of ozone-depleting chemicals.¹⁵³

It is significant that despite recent studies, the most serious factor, CO₂ emissions, has not yet been successfully addressed in a multinational format. Testimony at Hearings before the United States Senate Committee on Energy and Natural Resources is illustrative of the perceived negative economic impact of cutbacks in CO₂ emissions. Dr. Michael Oppenheimer of the Environmental Defense Fund, testifying June 23, 1988, urged that the time for action "is NOW."¹⁵⁴ Dr. William P. Moomaw, Director of the Climate, Energy and Pollution Program at the World Resources Institute, reiterated that a correlation between chemicals and global warming in the range of sixty percent probability is not a chance event. He urged steps be taken quickly to find substitutes for CFCs, and to reduce the rate of carbon dioxide emissions.¹⁵⁵

Dr. James Decker, Acting Director of the Office of Energy Research, Department of Energy, by contrast stated:

We do not, and cannot, require absolute certainty in climate models What we do require is improved climate models that can provide reliable, regional projections of climate parameters that can then be used by resource analysis to generate

151. WRI 1986, *supra* note 1, at 199.

152. Handl notes that traditionally, "Third World aid demands have been framed in terms of donor countries' moral obligation to redress past wrongs of colonialism, or in the nature of appeals to international solidarity. Now, Third World countries could make a plausible argument for the right to be compensated to the extent that they incur opportunity costs by foregoing development options to preserve environmental resources." Handl, *Environmental Protection and Development In Third World Countries: Common Destiny—Common Responsibility*, 20 N.Y.U.J. INT'L L. & POL. 608 (1988).

153. Houston Chron., July 12, 1990, at 29A, col. 2.

154. *Hearings*, *supra* note 45, at 84 (statement of Dr. Michael Oppenheimer of the Environmental Defense Fund).

155. *Id.* at 142-43 (testimony of Dr. Moomaw, Director, Climate, Energy and Pollution Program, World Resources Institute).

integrated quantitative regional projections of the combined effects of increasing CO₂ and climate change on our resources. Without this level of detail, it would be premature to assign "threshold" values that would be used to trigger policy actions.¹⁵⁶

[D]ata are lacking to resolve the differences between the model estimates of greenhouse-induced warming and observed warming [T]he models could be overestimating the warming by a factor of two because of the lack of, or the crude formulation of, data on, and models of, an important climate process. For example, clouds can act to enhance or moderate the warming, and several scientists have estimated that moderation by clouds could have been by as much as a factor of two, thus canceling half the warming [C]loud data and models are insufficient, at the present time.¹⁵⁷

The United States Department of Energy (DOE) thus advocated a cautious approach of waiting until more is known, citing uncertainties and the possibility of overestimating the warming.¹⁵⁸ There is some indication that this policy has softened; in January of 1990 the DOE recommended an energy conservation campaign that would promote use of renewable fuels. Deputy Secretary W. Henson Moore stated the campaign, if carried out, could save "2.6 million barrels of oil a day, reduce emissions of air pollutants by 5.2 million tons a year and eliminate the need to build 15,000 megawatts of electric generating capacity" (equaling about fifteen full-sized power plants).¹⁵⁹ Nevertheless, the United States still resists definitive caps on CO₂ emissions.¹⁶⁰ President Bush refuses to implement these measures because they may threaten the

156. *Hearings, supra* note 45, at 269 (written answers of Dr. James F. Decker). Contrast this approach with comments by NCAR Senior Scientist Stephen Schneider that it is irresponsible to demand scientific certainty. He states that climate models will not be able to predict future change with any certainty until the climate system itself performs an "experiment." Failure to determine action now, which must be based on values rather than the scientific method, may affect the ability to slow down the rate of change. Rapid warming would be catastrophic. In other words, failure to act or under-react has costs. *Schneider, supra* note 69, at 25, 53.

157. *Hearings, supra* note 45, at 273 (supplemental report to statement of Dr. James F. Decker, Acting Director, Office of Energy, Research, Department of Energy, given Nov. 13, 1987). Hesitancy still exists at high levels in the U.S. government to act definitively regarding reduction of CO₂ emission levels. *Houston Chron.*, July 10, 1990, at 17A, col. 6 (statement by White House Chief of Staff that 96% of CO₂ comes from natural sources); *Houston Chron.*, July 12, 1990, at 23A, cols. 2-6 (caps on CO₂ could halt U.S. economic growth).

158. *Id.* at 272-73.

159. *Houston Chron.*, Jan. 27, 1990, at 1B, col. 2, and 3B, col. 2.

160. *See supra* note 174 and accompanying text.

employment of many Americans or threaten the nation's economic growth.¹⁶¹ The United States Department of Energy has stated and the Administration continues to feel that:

While the United States contribution to the greenhouse effect is important, measures to prevent or slow the rate of global warming will require international solutions The United States contribution to any reduction in the emission of greenhouse gases would have limited effect on the rate of growth of these gases The Department does not support unilateral domestic regulation of greenhouse gases [I]t seems particularly ill advised to impose the costs in unemployment and monetary expenditures on the American people. Should the United States Government determine that some control policy action is desirable, then the appropriate course of action is to seek international agreement on collective action which will be more effective and equitable.¹⁶²

The United States Senate has been more willing to take positive measures in relation to global warming. On February 6, 1990, Senator Albert Gore, R-Tennessee, submitted the "Appeal by American Scientists to Prevent Global Warming" into the Senate record.¹⁶³ That same day, the Senate unanimously passed the National Global Change Research Act of 1989 (S.B. 169). This bill recognizes the global climatic impact of human activities, the need for further research and action, and the need of the United States to assume a position of leadership. The bill addresses emissions of both CFCs and CO₂. Significantly, portions of the ensuing discussion addressed the major economic costs that can be associated with adverse global warming.¹⁶⁴

There are also indications that several major industrialized nations are ready to move forward to actively reduce CO₂ emissions. A resolution, issuing from a United States Senate-sponsored conference on global warming in May 1990, was supported by forty-two nations and called for a fifty percent reduction by the year 2010 in current levels of greenhouse

161. Houston Chron., July 12, 1990, at 23A, cols. 2-5.

162. *Hearings, supra* note 45, at 279 (written responses of James F. Decker, DOE).

163. This appeal called for increased standards in motor vehicle fuels, substantial increases in federal funding for research on energy efficient technologies, further development and commercialization of renewable energy sources, and other measures encouraging research and development. The appeal was signed by over 700 members of the National Academy of Sciences, including 49 Nobel laureates. 136 CONG. REC. S776-79 (1990) (daily ed. Feb. 6, 1990).

164. S.B. 169, 101st Cong., 2d Sess., 136 CONG. REC. 808-18 (1990). Comments were by Senator Hollings of Arizona. *Id.* at 813.

pollutants, including CO₂.¹⁶⁵ At the 1990 Economic Summit, Britain offered to stabilize British emissions at present levels by the year 2005, as long as other nations would also participate to the effort. West Germany recently adopted a policy to reduce CO₂ emissions twenty-five percent from 1987 levels within fifteen years, and urged that radical measures be taken in an international climate treaty by 1992.¹⁶⁶ Earlier this year, France became the first nation to institute a tax on air pollution, although limiting it to sulfur dioxide pollution.¹⁶⁷ While the United States continues to resist caps on CO₂ emissions, arguing such measures would inhibit economic growth,¹⁶⁸ other nations feel these reductions are compatible with a robust economy and point to Japan as an example.

The Communique issuing from the Economic Summit on July 11, 1990, did recognize the importance of developing new technologies to reduce CO₂ emissions, and supported accelerated scientific and economic research on the impact of climate change and potential responses. The Communique also directly addressed the problem of deforestation as it contributes to CO₂ emissions and other problems, urging the development of a plan of action by the World Bank to specifically address the issue in Brazil. The Communique also called for a global forest convention or like agreement by 1992.¹⁶⁹ Martin Khor of Malaysia, director of the Third World Network, a coalition of two hundred environmental groups in various countries, welcomed the provision but reiterated that some compensatory mechanism must be developed to give tropical nations an economic incentive to stop deforestation.¹⁷⁰

The impact of so many recent studies, the recent aggressive proposals from West Germany and Britain, and modifications to the Montreal Protocol that encourage participation by developing countries such as India and China, all indicate that the international community is ready to take steps toward aggressive solutions. The upcoming United Nations Conference on Environment and Development scheduled to be held in

165. Houston Chron., May 2, 1990, at 15A, cols. 1-2.

166. Houston Chron., July 10, 1990, at 21A, col. 5.

167. Wall St. J., March 18, 1990, at A7, col. 3.

168. Houston Chron., July 12, 1990, at 23A, cols. 4-5. President Bush's Chief of Staff John Sununu is credited with shaping the administration's resistance to CO₂ emission limits. This position seems to directly impede the recent report of the IPCC (*supra* note 157) which calls for a 60% reduction in CO₂ and other greenhouse gases. That report attributed 56.2% of greenhouse gas emissions to energy use, 21.2% to agriculture, 15% to refrigeration and cooling, and 1% to industry. Houston Chron., July 10, 1990, at 21A, col. 5.

169. Communique from the 1990 Economic Summit, Houston, Texas, *reprinted in* Houston Chron., July 12, 1990, at 29A, cols. 3-4 and 30A, col. 1.

170. Houston Chron., July 12, 1990, at 27A, col. 5.

Brazil in 1992 looks to establish a binding climate treaty and an environmental agenda for the next century.¹⁷¹

However, the environmental problems of Eastern Europe have yet to be addressed. These financially limited nations, where air and water pollution contribute to make life expectancy the shortest of all industrialized nations, will need assistance in meeting emission goals.¹⁷²

Problems of other developing nations will also need to be addressed in conjunction with steps taken by industrialized nations. For instance, it may be necessary for developed countries to use state of the art technology immediately, even at the cost of economic growth, in order to permit the Third World countries to develop. These developing nations could be required to use the most efficient design in coal-burning plants, but could hardly be required to eliminate coal consumption. The United States, by contrast, could be required to eliminate coal burning entirely.¹⁷³

Innovative solutions may provide answers. One recent proposal recommends fertilizing the oceans with iron, which would encourage growth of marine algae called phytoplankton. These plants need iron to convert nutrients such as nitrogen into amino acids, and would soak up much of the excess carbon dioxide in the atmosphere.¹⁷⁴

V. EVALUATION AND CONCLUSION

Over the last twenty years, there have been significant changes in international law as related to the environment. Since 1972, when large-scale attention first turned to the atmosphere as a common resource, many studies have established a clear link between certain chemical by-products of human activities and negative atmospheric impacts.¹⁷⁵ International law in the beginning focused on the rights of the sovereign nation, but now attempts to elicit the cooperation and exchange of information. Recent developments have even led to multinational agreements to reduce production, consumption, and trade in certain chemi-

171. Houston Chron., June 18, 1990, at 4A, col. 6

172. Houston Chron. June 18, 1990, at 4A, col. 6; Houston Chron., July 10, 1990, at 21A, col. 6. Emerging noncommunist governments must deal with many problems inherited from regimes that worried little about environmental issues. Many environmental organizations and research groups are also concerned that Eastern Europe does not become a dumping ground for wastes, or the recipient of "environmentally damaging" Western technologies. *Id.*

173. *Schneider*, *supra* note 69, at 56.

174. San Jose Mercury News, May 20, 1990, at 18A, cols. 1-4. This research proposal has been endorsed by a special panel of the National Research Council, an arm of the National Academies of Sciences and Engineering. The experiment could be implemented at an estimated cost of \$50 million to \$150 million, and might first be conducted off the coast of Antarctica or Alaska. *Id.*

175. *See supra* notes 64, 67, 70, and 87.

cal.¹⁷⁶ As yet, however, noncompliance problems have not been addressed. There is no procedure to compel compliance and there are no provisions for sanctions. At this stage, compliance and participation are entirely voluntary.

Customary international law may currently obligate states to notify neighboring states of potential environmental damage from activities, if there is a *prima facie* risk of injury. However, no corresponding legal obligation exists relating to the export of substances or technologies which are hazardous to the environment.¹⁷⁷ Recommendations that would require a "prior informed choice" have been fiercely opposed, but are gaining some acceptance in the area of transboundary movement of hazardous wastes.¹⁷⁸

International standards concerning multinational corporations may give rise to expectations that the state of incorporation is legally obligated to assure the "good behavior" of its corporate nationals.¹⁷⁹ Multinational corporations in the chemical industry, such as DuPont,¹⁸⁰ are in a position to substantially impact the world community. Industries' voluntary cutback on production of CFCs may have a greater impact on other chemical companies than any international punitive measures.¹⁸¹

New studies will be directed toward the analysis of the negative economic impact of ozone depletion. Recent 1988 testimony before the Senate Committee on Energy and Natural Resources by Dr. William Moomaw¹⁸² indicates that quantitative analyses of the costs of the greenhouse effect are just beginning. Nevertheless, economic costs to the United States alone, should a global warming take place, can be extrapolated by using costs of the 1988 drought. Evaluating costs to crops, navigation, and power generation, "the Bellagio Report suggests that mitigation costs might lie in the range of several hundred billion dollars by 2030."¹⁸³

176. Protocol, *supra* note 9.

177. Handl, *supra* note 152, at 615-16. Third World countries often lack the administrative infrastructure to respond promptly to a notification. They also often lack the ability to carry out a risk/benefit assessment, an environmental impact assessment increasingly required by multilateral development banks prior to commitment of funds to a development project. Some feel that exporting countries should therefore be held to a higher standard than simple prior notification.

178. *Id.* at 617.

179. *Id.* at 624-625.

180. See *supra* note 47 and accompanying text.

181. *Ozone Depletion*, *supra* note 2, at 461.

182. *Hearings*, *supra* note 45, at 187 (statement of Dr. William Moomaw, Director, Climate, Energy and Pollution, World Resources Institute).

183. *Id.* See also *supra* note 133.

Further apportionment of costs resulting from acid rain damage in Europe will motivate harmonization of national environmental regulations as well as encourage compliance. National self-interests are being weighed with international interests.

Greater participation in multinational preventative agreements such as the Montreal Protocol is imperative. The Protocol as amended must provide not only developing nations with incentives to participate, as the new fund and the ten year grace period are designed to do,¹⁸⁴ but it must also provide chemical and user industries with sufficient economic incentives to encourage development of substitutes for all major uses of CFCs.¹⁸⁵ For example, the potential demand for substitutes in low-consuming countries constitutes an important incentive for firms in the EEC.¹⁸⁶

Developing nations need both the incentive and the economic capabilities to participate. Even troublesome areas of population pressure are interrelated, and solutions must address these issues. Inexorably expanding populations present the greatest obstacle to overcoming poverty and abusive environmental practices.¹⁸⁷

Remedial action will be ineffective unless all nations, including developing states, view it in their national interest to act. It will be necessary to achieve sustainable development—which implies economic growth. This will not be feasible without massive financial or technical assistance from wealthier nations. Innovative financial assistance programs, such as debt-for-conservation swaps, represent a first step in this direction and are beginning to be established.¹⁸⁸ President Bush recently proposed a Latin American initiative that addressed the issue of debt-relief. The initiative allowed for “special breaks” for countries supporting environmental preservation efforts in a “debt for nature” swap program.¹⁸⁹

There must also be a shift away from the traditional territorial focus of international law to a focus allowing for international responsibility. One alternative is to adopt standards enhancing the development and usefulness of data regarding transfer of hazardous technology or substances. Parties must be put in a position to evaluate, in an informed manner,

184. Comment, *International Agreements—Montreal Protocol on Substances that Deplete the Ozone Layer*, 29 HARV. INT'L L.J. 185-86 (1988). See also *supra* note 141 and accompanying text regarding the recent Amendment to the Protocol.

185. Tripp, *supra* note 138, at 748.

186. *Id.* at 750.

187. Handl, *supra* note 152, at 608-609.

188. *Id.* at 607-09.

189. Houston Chron., June 28, 1990, at 22A, col. 5.

the costs and benefits of a contemplated trade. Export-authorizing countries, as well as multilateral development banks, may have to assess the potential local impact prior to a decision allowing export or financing.¹⁹⁰ These developing ideas reflect the sentiment that exporting industrialized countries and multilateral financing institutions should share the responsibility for the safe and environmentally sound application of development aid.¹⁹¹

Solutions to the global environmental problem are not readily available. A necessary first step requires understanding the global scope of the problem. The second step requires a willingness to cooperate. Third, effective measures must be discovered that will successfully mitigate the crisis. Fourth, and perhaps most difficult, is the willingness to sacrifice some national interests for the good of all nations and the global atmosphere. The critical question remains whether there is time to develop institutions and responses slowly, when problems of ozone depletion and global greenhouse warming seem to escalate so rapidly and irreversibly.

Roberta Dohse

190. Handl, *supra* note 152, at 614-15.

191. *Id.*