Michael Lisowski

Driving International Environmental Co-operation: The Role of Incentives in the Creation of the Montreal and Kyoto Protocols.

Currently Pursuing:	PhD International Relations, University of Cambridge
Previous Degrees:	MA Economics, University of Toronto, 2000
	MPhil International Relations, University of Cambridge, 1999
	BA Honours Political Science, Bishop's University, 1998

On September 16, 1987, the international community made a surprising, substantive commitment to protect the global environment. The signing of the *Montreal Protocol on Substances That Deplete The Ozone Layer* committed parties to a 50% reduction in ozone depleting chlorofluorocarbons (CFCs) by 1998. At the time, the world-wide production of CFCs was a $100 billion a year industry, and anthropogenic ozone depletion had *not* yet been measured. In 1998, after successive revisions to the Protocol, ozone depletion over Antarctica stabilised: the international community had acted to redress ozone depletion quickly and decisively, in spite of uncertain science. The Protocol was recognised as the most successful international environmental treaty ever signed,[1] a 'lasting model',[2] a 'prototype' for future environmental co-operation.[3]

This model did not, however, fare well during the climate change negotiations. After years of tortuous negotiation, the *Kyoto Protocol To the United Nations Framework Convention on Climate Change* was signed in 1997. Developed countries adopted individualised emission abatement targets under this Protocol, amounting to a 5.2% reduction in total greenhouse gas (GHG) emissions among developed countries from 1990 levels by 2008-2012.[4] However, since developing nations account for approximately 45% of global GHG emissions, the Kyoto Protocol actually allows for an increase of world-wide GHG emissions over the commitment period of about 31%.[5]

It is easy to dismiss the fact that the Kyoto Protocol failed to live up to the Montreal Protocol's example. Attempting to allay climate change is a more complex and

---

[1] Kauffman 1997: 74.
[2] Benedick 1991a: 210.
[3] Litfin 1994: 7.
[4] See Annex I, *Table II: Kyoto Protocol Commitments.*

costly task than preventing ozone depletion. The greater number of countries involved in the production of GHGs than were involved in the production of CFCs made co-operation more difficult to achieve in Kyoto than in Montreal. Additionally, unlike CFCs, the principal greenhouse gas, carbon dioxide, is a by-product of most energy consumption, so a significant reduction of GHGs is only possible at the cost of economic growth. Few developed countries, let alone developing countries, are willing to sacrifice any amount of economic growth when they cannot be certain that climate change exists, or that GHG reductions will prevent it.

Explaining differences in the Kyoto and Montreal Protocols with reference to vague notions of complexity and cost is, however, superficial and not very enlightening. A far more fruitful approach is to recognise the ozone layer and climate system as global public goods and to explain the Protocols' different results with reference to different strategic conditions that necessarily led to different levels of public good provision. In negotiating the Protocols, states strategically determined the costs and benefits of co-operative action to provide the public good in question, compared those with the potential costs and benefits of inaction, and came up with a cost-sharing scheme once co-operation was deemed necessary. A game theory analysis, which assumes states rationally pursue public and private goods, explains the strategic dynamics of the Montreal and Kyoto negotiations, and reveals the fundamental reasons why the Kyoto Protocol failed to live up to the example set by the Montreal Protocol.

---

[5] Grubb 1999: 156.

This article argues that the Prisoners' Dilemma characterises the strategic interactions of states involved in the production of noxious emissions, be they ozone depleting chlorofluorcarbons (CFCs) or climate altering greenhouse gases (GHGs). It is further contended that the Prisoners' Dilemma payoff matrix can be more conducive or less conducive to co-operation if the relationship between costs and benefits is altered under realistic assumptions. These arguments lead to two hypotheses: first, that states will not undertake unilateral emissions reductions because doing so is not in their interest; and second, that the payoff matrix associated with CFC emissions reductions is substantially different from the one associated with GHG emissions reductions and therefore encourages rather than discourages co-operation. The article tests these hypotheses against the reality of the GHG and CFC emission reductions and the negotiation of the Montreal and Kyoto Protocols. The wider implications of the analysis are considered by way of conclusion, both with respect to future international environmental co-operation and the provision of public goods in general.

I. Collective Action To Mitigate Ozone Depletion and Climate Change: Theoretical Insights

Underlying the scientific problems of ozone depletion and global warming is the political problem of collective action. The issue of collective action arises because the ozone layer and the climate system are public goods: the benefits of an ozone layer and a stable climate are free to be enjoyed by everyone, and each individual's consumption of these benefits has no effect on their 'availability' to others. Most public goods, like police forces, defence forces, public health care, and education, are provided with the help of coercion: citizens are forced to pay their share of the costs through taxation and the police have the power to punish free-riders (those who try to receive the benefits of these goods without contributing to their cost).[6] Of course, these kinds of enforcement mechanisms are rarely feasible on the international level. The protection of the ozone layer and climatic system can only be achieved through enforceable international agreements.

The challenge is to create agreements that circumvent the tendency of states to maximise their individual expected payoffs by over-polluting. For simplicity, imagine a two-country world where the distribution of costs and benefits is symmetric, and the sustainable threshold of noxious emissions is 20 units. The maximum emission that each country can make without compromising the threshold or infringing on the other country's hypothetical production rights is 10 units. If one country over-emits, it will gain profit from the additional units of emissions, but also cause some welfare-reducing environmental deterioration. The over-producing country may experience a net welfare gain thanks to the increased profit, but the other country will have necessarily experienced a net decrease in welfare. That country's only chance to regain some of its lost welfare is to increase its profits by overproducing as well. Regardless of the actions of the other state, production beyond the sustainable amount always offers higher welfare (see Figure I).

[6] Russet and Sullivan 1971: 864.

Figure I. Stylised Prisoners' Dilemma.

		B's Emissions: More than 10 units	B's Emissions: 10 units
A's Emissions	More than 10 units	* A: (20-12)=8 B: (20-12)=8	A: (20-5)=15 B: (10-5)=5
	10 units	A: (10-5)=5 B: (20-5)=15	A: (10-0)=10 B: (10-0)=10

Note: * indicates equilibrium.[7] Payoff figures reflect net welfare (units of profit – units of cost due to environmental degradation). Profit per unit is assumed constant at $1. The marginal cost of environmental degradation is assumed to increase as emissions rise (hence the subtraction of $12 of social welfare when both countries are producing more than 10 units, and the subtraction of only $5 when only one is producing more than 10 units).

Of course, if the logic of the Prisoners' Dilemma properly characterises individual CFC and GHG emissions production decisions[8], then it must characterise the decision to co-operate and reduce CFC and GHG emissions to a sustainable level. The strategic interactions of states facing this decision are demonstrated in Figure II. If states choose not to co-operate, then they accept the status quo and their marginal payoff is 0 (the decision to do nothing neither increases nor decreases their expected welfare). Neither state will ever unilaterally reduce emissions, since they will receive a net marginal payoff of –2 (8 units of benefit minus 10 units of cost) if they do. However, they will try to co-operate and receive 6 units of benefit each (16 units of benefit minus 10 units of cost). The difficulty that arises is that each knows that the other will be tempted to free-ride and receive 8 units of benefit, and neither wants to be duped into receiving a payoff of –2.

---

[7] The equilibrium position is derived as follows. If country B assumes that country A will choose to overproduce, its best option is also to overproduce because that maximizes its welfare; if B assumes that A will not overproduce, B will still overproduce because that will maximize its welfare in this case as well. Consequently, B's strategy will always be to overproduce. Assuming A behaves strategically, A will anticipate B's overproduction and maximize its welfare by overproducing as well.

[8] For the purposes of the arguments here, whether this logic is actually applied or not is irrelevant: as long as decisions are made as though this logic is being applied, the analysis and conclusions will hold.

Figure II. The Decision to Co-operate and Reduce Emissions.

		B's Strategy	
		Not co-operate	Co-operate
A's Strategy	Not co-operate	A: 0 * B: 0	A: 8 B: -2
	Co-operate	A: -2 B: 8	A: 6 B: 6

Assumptions: a) Benefits conferred to all states from an emissions reduction: b=8
b) Each country's cost of reducing emissions: c=10

Note: * indicates equilibrium.

Figure III extends this analysis to a multi-country world. Assume that every country that reduces emissions confers a benefit of 8 to country *A*. So if 5 countries reduce emissions and country *A* free-rides on the efforts of the other countries, it receives a benefit of 40 without doing anything. Meanwhile, assume that country *A*'s cost of reducing emissions is 10, so if country *A* is the only country that reduces its emissions, it receives –2 (its benefits of 8 minus its cost of 10). If all six countries reduce emissions including *A*, *A* receives 38 units of benefit (48 units of benefit minus its 10 units of cost). Regardless of the number of reducing countries, the payoff to *A* is always larger if it does not reduce emissions (the numbers in the top row of the Figure II are always larger than those in the bottom row): so *A* always prefers to free-ride. Since every country will engage in the same reasoning as country *A*, no country will reduce emissions and all countries will receive a payoff of 0 in the absence of an agreement to co-operate. Such an agreement is desirable, of course, because it yields a high payoff, but is difficult to achieve because of the huge incentive to free-ride.

Figure III: Six-country Prisoners' Dilemma

	A	Country 1	Country 2	Country 3	Country 4	Country 5
Country A Does Not Reduce Emissions	0	8	16	24	32	40
Country A Reduces Emissions	-2	6	14	22	30	38

At this point, it may appear that co-operating to reduce CFCs and GHGs is equally desirable and equally difficult because in both cases, states are caught in the Prisoners' Dilemma. However, varying the relationship between costs and benefits on the basis of reasonable assumptions can dramatically change the likelihood of co-operation.

If, for instance, there is significant scientific uncertainty regarding the extent and cause of the environmental deterioration, the perceived benefits of emissions reductions might actually be much smaller than they are in Figures II and III. In the extreme case presented in Figure IV, the benefits are so small that there is no incentive to co-operate at all.

Figure IV. Deadlock.

		B's Strategy	
		Not co-operate	Co-operate
A's Strategy	Not co-operate	A: 0 * B: 0	A: 2 B: -8
	Co-operate	A: -8 B: 2	A: -6 B: -6

Assumptions: a) Benefits conferred to all states from an emissions reduction: b=2
b) Each country's cost of reducing emissions: c=10

Note: * indicates equilibrium.

Obviously, the larger the collective payoff from co-operation, the more likely states are to co-operate. In Figure V, the costs of reducing emissions are assumed to fall if both countries reduce emissions. This is likely to be the case if a portion of the costs associated with unilaterally reducing emissions are due to a loss in competitiveness. Although both Figure V and Figure II describe the decision to reduce emissions in terms of the Prisoners' Dilemma, co-operation is far more likely in Figure V. The size of the payoff for co-operating is higher when costs are falling: compare Figure V with Figure II, the payoff is 7 each as opposed to 6 each. Moreover, the incentive to free-ride is lower when costs are falling: the advantage of not reducing emissions when the other country is reducing emissions is only 1 (8-7: see Figure V) compared with 2 (8-6: see Figure II).

Figure V. Prisoners' Dilemma with Falling Costs.

		B's Strategy	
		Not co-operate	Co-operate
A's Strategy	Not co-operate	A: 0 * B: 0	A: 8 B: -2
	Co-operate	A: -2 B: 8	A: 7 B: 7

Assumptions: a) Benefits conferred to all states from an emissions reduction: b=8
b) Each country's cost of reducing emissions: c=10
c) If both countries reduce emissions costs fall: c=9

Note: * indicates equilibrium.

Of course, the benefits of emissions reductions may vary across states if, for instance, a country's geographic location makes it particularly susceptible to the adverse effects of ozone depletion or climate change. Alternatively, the costs of emissions reductions may vary across countries if some countries are very large, efficient emitters and others are very small, inefficient emitters. Figure VI illustrates the case of varying benefits across countries.

Figure VI. Prisoners' Dilemma with Uneven Benefits.

		B's Strategy	
		Not co-operate	Co-operate
A's Strategy	Not co-operate	A: 0 * B: 0	A: 8 B: -4
	Co-operate	A: -2 B: 6	A: 6 B: 2

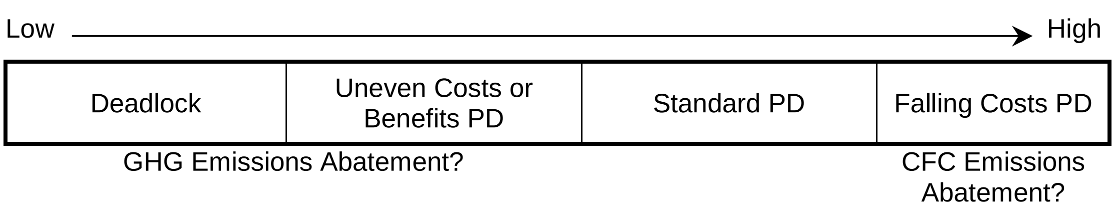
Assumptions:
a) Benefits accruing to A from an emissions reduction: b_A=4/7*b
b) Benefits accruing to B from an emissions reduction: b_B=3/7*b
c) Benefits of an emissions reduction: b=14
d) Each country's cost of reducing emissions: c=10

Note: * indicates equilibrium.

Co-operation is still clearly a possibility, since the co-operative outcome is better than the non-co-operative outcome, but it is very unlikely. Certainly, the potential for co-operation is lower than in the situation described in Figure II because of the lower payoff for country *B* if co-operation is achieved (2 instead of 6) and the greater potential for free-riding by country *B* (it can gain 4 from free-riding compared with 2). But the uneven distribution of benefits makes co-operation to reduce overall emissions to a sustainable level difficult to achieve for another reason: since each country faces a unique net payoff for a given emissions reduction, each will advocate a different reduction level depending on when its marginal benefit of reducing emissions equals its marginal cost. In the example above, Country *B* will be unwilling to accept the cost of 10 necessary to lower emissions to the sustainable level if a slightly higher level of emissions can be achieved at far less cost, thereby increasing its net payoff. Significant emissions reductions are only likely to be achieved if the majority of the benefits from reductions accrue to the countries facing the majority of the costs (the largest emitters and/or the most efficient emitters). Similarly, if there is an uneven distribution of costs and benefits across generations, emissions will only be reduced to a sustainable level if the generations facing the majority of the costs also receive the majority of the benefits.

Clearly, the likelihood of a public good's provision is not fixed by the Prisoners' Dilemma payoff structure, but varies with the size of the collective payoff, the likelihood of free-riding, and the nature of the distribution of costs and benefits across countries and generations. Figure VII synthesises the discussion by ranking the matrices according to the likelihood of co-operation implied by each. Moving from left to right, co-operation is more desirable because of a progressively larger collective payoff, and is easier to achieve because of a progressively lower potential for free-riding and/or a more favourable distribution of costs and benefits.

Figure VII. Likelihood of Public Good Provision.



Note: PD refers to Prisonners' Dilemma.

Two hypotheses can, therefore, be ventured regarding ozone depletion and global warming. First, if the Prisoners' Dilemma accurately characterises GHG and CFC emissions production decisions, no country will undertake a unilateral emissions reduction because doing so will only be to its detriment. Second, the failure of the Kyoto Protocol to live up to the Montreal Protocol is because, in comparison with the CFC regime established by the Montreal Protocol, the magnitude of a GHG abatement regime's payoff was small, the distribution of its costs and benefits unfavourable, and the likelihood of free-riding high.

II. Unilateral Commitments

Prior to signing the Montreal Protocol, Canada, Norway, and Sweden adopted unilateral bans on the nonessential use of CFCs, and the EU adopted a production cap and a 30% unilateral reduction in nonessential CFCs. Similarly, many industrialised countries adopted voluntary GHG reduction commitments prior to the Kyoto Protocol.[9] However, in all cases there is strong evidence to indicate that they were either false commitments, or commitments that were not to entail significant, if any, costs.

The purpose of the unilateral CFC 'aerosol bans' was to eliminate the nonessential use of CFC-11 and CFC-12. It was a 'no regrets' measure, worth undertaking given the possibility of ozone depletion because it would scarcely affect the economies in question. There were alternative delivery mechanisms for most products using these CFCs (such as 'roll-on' applicators for deodorants) – hence the term 'nonessential use'. Moreover, nonessential CFC production was a declining industry. In fact, American consumption of nonessential CFCs had dropped by over two-thirds before the ban was adopted.[10] European consumption had dropped by 28% when the 30% reduction target was set by the EU in 1980. The EU production capacity cap at 1980

---

[9] See Annex I, *Table I: Voluntary Reduction Commitments by March 1992.*

levels was also disingenuous: it allowed a 60% increase in CFC production because 'capacity' was defined by 24-hour continuous plant operation.[11]

The unilaterally adopted GHG stabilisation and reduction 'targets'[12] were similarly unambitious. Natural economic restructuring had made stabilisation a reality. Virtually all growth in carbon dioxide emissions in the 1980s among OECD countries was in the US, Japan and the UK. Those countries that went beyond stabilisation, such as Germany and the Netherlands were feeling 'green' electoral pressure, but they also had falling carbon dioxide emissions.[13] Faced with rising emissions, the US maintained only a 'provisional' target until 1993, and Japan adopted a per capita stabilisation target which permitted growth in total emissions. The UK set a target that was contingent on a similar American commitment because it feared a unilateral commitment would result in a loss of competitiveness. The European Community, meanwhile, set a stabilisation target for the Community as a whole under the assumption that any increases in the UK would be offset by decreases already occurring in countries like Germany. New Zealand's commitment was an ambitious 20% carbon dioxide reduction from 1990 levels by 2000, "subject to certain conditions, including cost-effectiveness, [and] not reducing our competitive advantage in international trade".[14] When stabilisation eventually proved to be out of reach for some countries, they issued 'clarifications'. Australia and Canada broadened their mandate to include all GHGs. Norway offset its increases in emissions by crediting itself for aid programs abroad. Ireland similarly credited itself for

---

[10] Benedick 1991a: 28.
[11] Benedick 1991a:25.
[12] See Annex I, *Table I: Voluntary Reduction Commitments by March 1992.*
[13] Brenton 1994: 174.

reforestation.[15] Ultimately, and in accordance with game-theory prediction, “No country met a [unilateral] target because of discreet policy on climate change.”[16]

III. The Perceived Costs and Benefits of Emissions Abatement

The perceived magnitude of the collective payoff of CFC and GHG emissions abatement depends on an assessment of the costs and benefits of emissions abatement, which in turn depends on scientific knowledge of ozone depletion and climate change.

Ozone depletion was just a theory at the time of the Montreal negotiations. Calculations of the impact of CFCs on the ozone layer were supported by laboratory experiments, but anthropogenic ozone depletion had yet to be measured. Predictions of ozone depletion ranged wildly over time.[17] The National Academy of Science, for instance, predicted ozone losses of 2-20%, 16.5%, 5-9%, and 2-4% in 1976, 1979, 1982, and 1984 respectively.[18] The most comprehensive report issued prior to the negotiations, the 1985 WMO Report, predicted a 9% decline in ozone concentrations by 2050 based on rising CFC emissions;[19] however, it found no actual evidence of anthropogenic ozone depletion. It concluded that there was “…little overall support for the suggestion of a statistically significant [downward] trend” in global ozone levels.[20]

Measurements of the Antarctic hole in the ozone layer were the first to attest to ozone depletion and several authors contend that the hole’s discovery was a key influence

---

[14] FCCC/NC/2 1995: 3.
[15] Brenton 1994: 189
[16] Drexhage 1999: Interview.
[17] See Annex II, *Graph II: Various Predictions of Ozone Depletion, 1974-85.*
[18] See Roan 1989: 112.
[19] WMO/NASA 1985.
[20] WMO/NASA 1985: 8.

during the negotiations;[21] however, a number of factors make this highly unlikely. Firstly, the hole was not attributed to CFCs until the 1988 Ozone Trends Panel Report and a series of other scientific reports were issued, after the conclusion of the Montreal Protocol.[22] There certainly was "no clear link between manmade pollutants and ozone depletion" [23] during the negotiations. Secondly, the hole in the ozone layer was not predicted by any of the atmospheric models, not even those that predicted ozone depletion, and may therefore have increased the sense of scientific uncertainty. As one scientist noted a month before the conclusion of the negotiations:

> This phenomenon in Antarctica was absolutely unexpected, absolutely unpredicted. We don't know if it's chemistry, we don't know if it's [atmospheric] dynamics.[24]

Thirdly, Dr. Robert Watson, lead author of the WMO Report, advised negotiators that it would be imprudent to base any decisions on the presence of the hole.[25] Though the hole's discovery may have increased a sense of urgency, it "…did not... provide any clear signal for policymakers at that time".[26] The causal link between CFCs and ozone depletion remained in doubt for the duration of the negotiations.

However, scientific knowledge of the link between increasing levels of UV-B penetration and increasing levels of skin cancer, cataracts, and damage to agriculture and fisheries was well established before the negotiations began. This link did provide a clear signal for policymakers. As former chief US negotiator Richard Benedick notes:

---

[21] See for example, Brenton 1994: 138, Litfin 1994: 80, Young 1989b 372.
[22] For an overview, see Rowland 1989.
[23] Schoeberl 1986: 1191.
[24] Quoted in Zurer 1987: 8.
[25] United Nations Environment Program UNEP/WG.148/3:15.
[26] Benedick 1991a: 19.

> All of these possible effects were known to the negotiators of the Montreal Protocol, and they were never seriously contested. It was generally accepted that changes in the ozone layer would pose serious risks to human health and the environment.[27]

The potential costs of inaction were in the forefront of the negotiators' minds and these were estimated to be extremely high. Indeed, the EPA estimated that a 50% reduction in CFC emissions from 1986 levels would save the US $6.4 trillion by 2075 in reduced cancer treatment costs alone.[28] The world-wide CFC industry was worth a mere $100 billion dollars in 1987. These numbers obviously encouraged large CFC reductions, even if the probability that CFCs cause ozone depletion was thought to be small.

Action was not, however, further encouraged by the discovery of CFC substitutes.[29] Just prior to the final Protocol negotiations, DuPont made the following surprise announcement:[30]

> …it would now be prudent to limit world-wide emissions of CFCs… [Moreover,] if the necessary incentives were provided, we believe *alternatives could be introduced in volume in… roughly five years*. (emphasis added)[31]

These alternatives had been isolated in the 1970s. The revelation of their existence provided a strong incentive for the US to push for stiff international regulation since it now knew it had little to lose: the substitute chemicals were the property of its own largest CFC producer, DuPont. But it also provided a countervailing incentive for the EU

---

27 Benedick 1991a: 22.
28 See EPA 1987b.
29 For a contrary opinion, see Sandler 1997: 113.
30 DuPont had claimed in March of 1986, just a few months before its announcement, that "there were no foreseeable alternatives available"(Hammitt and Seidel Interviews in Litfin 1994: 94).

to hold out for minimal reductions until its companies could develop their own substitutes. Few European companies were ever engaged in research for alternatives since they had not been exposed to a CFC aerosol ban, and no European company had yet isolated potential substitutes.[32] In an effort to stall regulation, the EU Commission ignored DuPont's statements in a communication to Ambassador Benedick and claimed that "no fully satisfactory fluorocarbon alternatives would become available in the foreseeable future".[33] Clearly, the discovery of CFC substitutes, like the discovery of the ozone hole, at best provided ambiguous incentives. Knowledge ozone depletion's effects was the primary driving force behind co-operation in Montreal.

In contrast to ozone depletion, knowledge of climate change's effects was highly uncertain, though the existence of climate change was not in dispute during the Protocol negotiations. The Intergovernmental Panel on Climate Change (IPCC) had published two influential reports, the first in 1990 and the second in 1996.[34] It was clear from these reports that what might be characterised as a 'very high', or 'high' consensus level existed among scientists regarding the increasing concentrations of GHGs in the atmosphere and their likely contribution to global warming. However, only a 'moderate' or 'low' level of consensus existed regarding the speed of this warming, and its consequences (see Table I).

---

[31] Glas 1986: 363-364.
[32] Brenton 1994: 139; Jachtenfuchs 1990: 275.
[33] Benedick 1991a: 69.
[34] Though the IPCC reports were the most influential, many non-IPCC reports were also considered by the negotiators, see FCCC/AGBM/1995/5: 1995 and FCCC/AGBM/1996/3 for an annotated list.

Table I: Scientific Consensus Regarding the Major Global Warming Claims[35]

Claim	Consensus Level
Concentration of GHGs will double by 2050	Very High
A doubling in GHG concentrations will result in a 1-4.5 degree Celsius rise in mean global surface temperature	High
Projected temperature increases will cause a rise in sea level of up to 2 meters in the next 100-150 years	Moderate
Warming of ocean surface water will accelerate evaporation that will in turn greatly amplify greenhouse warming (the 'super greenhouse' effect)	Low
Warming at poles will be higher than at the equator	High
While total precipitation will increase, regional droughts in continental interiors will also increase	Moderate
The rapidity of change will severely disrupt ecosystems	Low-Moderate
The West Antarctic ice sheet will melt within a few centuries	Low

Uncertainty regarding the effects of climate change are due to the unpredictable influence of aggravated hydrological cycles and potential feedback mechanisms. IPCC Working Group III noted in 1995 that there was no consensus on climate change's future costs because of this uncertainty:

> IPCC does not endorse any particular range of values for the marginal damage to CO_2 emissions, but published estimates range between $5 and $125 (1990 US) per tonne of carbon emitted now [in 1995].[36]

The regional estimates were thought to be even less certain than global estimates.[37] As a consequence, there was a disincentive for countries to undertake the relatively known cost of reducing GHG emissions.[38] Macroeconomic cost-benefit assessments of abatement (excluding potential social costs) for OECD countries range from between

---

[35] Table adapted from Hempel 1996: 94. Mathews 1991: 4 and Rathjens 1991: 159-163 make similar comments.
[36] Bruce 1996: 11.

–0.5% GDP (a gain of about $60 billion) to 2% of GDP (a cost of about $240 billion) per year over the next several decades.[39] Estimates for the cost of a 20% cut of carbon dioxide emissions in the US are as high 2.5% of GNP per annum.[40]

Clearly, the perceived payoff of GHG emissions abatement was much lower than that of CFC abatement. The scientific uncertainty associated with climate change nearly reduced the Kyoto negotiations to a deadlock. As New Zealand's Minister of the Environment, The Hon. Simon Upton notes with respect to climate change,

> …if we had known in 1992 how little we would still know about the natural carbon cycle today, we might never have signed the [United Nations Framework] Convention [on Climate Change] in the first place.[41]

Meanwhile, though the discovery of the ozone hole was of little effect, and the revelation of the existence of CFC substitutes produced countervailing incentives among the two most important CFC producers,[42] a strong consensus on the effects of ozone depletion provided a strong incentive to co-operate. On this basis alone, it is unsurprising that the Montreal Protocol commitments much stronger than those of the Kyoto Protocol. However, the distribution of costs and benefits and the likelihood of free-riding also contributed to this result.

---

[37] Bruce 1996: 11.
[38] Rathjens 1991: 172-173.
[39] Bruce 1996: 14.
[40] Brenton 1994: 168.
[41] Upton 1999: Interview.
[42] The EU and US accounted for 37% of world-wide CFC production each. See Annex I, *Graph I: Proportion of CFC Production by Region, 1984.*

IV. The Distribution of Costs and Benefits

The share of benefits accruing to polluting states and polluting generations from GHG emissions reductions is insufficient to offset the costs of substantial emissions reductions. The warming earth will produce winners and losers: countries with agricultural economies and large coast lines are expected to be losers, while relatively landlocked, industrialised countries are expected to be winners.[43] Yet, it is precisely these industrialised countries, the winners, that must be called upon to reduce GHG emissions for the benefit of the entire world. It is unlikely that they will take sufficient action.

The American commitment at Kyoto is a case in point. The Clinton Administration has estimated that the marginal cost of meeting its Kyoto targets ranges from $14 to $23/ton, assuming participation is full and implementation is cost effective.[44] Since most estimates of the global marginal damage of GHG emissions are similar[45], it would appear that the US Kyoto target is ideal. In fact, it is ideal only for countries like the US facing the average global marginal damage of GHG emissions. The uneven distribution of global warming effects means that states belonging to the Alliance of Small Island States (AOSIS), for instance, remain imperilled even if America and the other developed countries meet their reduction targets. These 37 island countries still face huge adaptation costs as the sea level rises. The expected ‘winners’ simply do not have an economic incentive to reduce emissions to a point that would ensure the long-term viability of these small island states.

[43] See Nordhaus 1994, Schelling in Dorfman & Dorfman 1993.
[44] Clinton Administration in Barrett 1998: 21
[45] Houghton et al. 1996: ch. 6.

This lack of an incentive among the 'winners' to significantly reduce GHG emission is compounded by the long atmospheric lives of GHG gases. These long lives imply that the positive effects of emissions abatement will only be felt in the distant future, though the costs of abatement will be incurred immediately. Stabilisation of carbon dioxide, methane and nitrous oxide concentrations requires cuts of 50%, 15-20%, and 70-80% respectively in their emissions. If these impossibly large cuts were undertaken, the equilibration of the climate system would still take centuries, as would the restoration of disturbed ecosystems.[46] Arguably, benefits accruing so far in the future represent no value to the current generation: human nature dictates that people only have an incentive to bear costs that are lower than the discounted, expected level of benefits they will receive in their lifetimes and the lifetimes of their children. Using a hypothetical discount rate of 8% over a period of two hundred years, $5 million in benefits accruing in the 200th year only justifies investing $1.03 today in climate change prevention. Because the welfare of the current generation is valued more highly than the welfare of future generations, there is a significant disincentive for any one generation to accept the immediate costs of stemming global warming,[47] as discounting demonstrates.

Discounting, meanwhile, is of little relevance to CFC reductions. Like global warming, ozone depletion will not stop any time soon. If there were an immediate 100% cut in CFCs, it would take sixty years before chlorine concentrations in the stratosphere

---

[46] Watson et al. 1996: 4.
[47] Undoubtedly, if a 'social discount rate' existed, it would treat intergenerational welfare equitably and be very low, or perhaps equivalent to zero. However, there is little evidence for the widespread adoption of such rate, which would at present constitute an unlikely act of intergenerational altruism. The difference between the discount rate and social discount rate would have to reflect an obligation to the future over and above any obligation currently felt for heirs, born or unborn, which is already reflected in individual time

returned to their 1985 levels – levels at which the Antarctic hole exists.[48] Nevertheless, unlike global warming, the effects of ozone depletion are already being felt, and the effects of additional emissions will be experienced by the current generation because of the speed at which the ozone layer deteriorates. Consequently, the current, polluting generation is encouraged to reduce CFC emissions.

Similarly, the primary polluting countries, the US, the Soviet Union, and Japan,[49] have an incentive to reduce CFC emissions because they are seriously threatened by ozone depletion. Of course, the effects of ozone depletion are most directly felt by countries close to the Antarctic hole. However, the incidence of skin cancer and other health problems in the US, USSR and Japan is expected to rise substantially, and the damage to fisheries and natural ecosystems is anticipated to be extensive.

V. Free-riding Opportunities

The larger the core group of countries responsible for shouldering the abatement costs, and the more disparate the members, the easier it is to free-ride and the more difficult it is to agree upon the creation of a strong abatement regime.[50]

In the case of ozone depletion, very few countries needed to be involved in the initial regime. Just three countries, Japan, the US and the Soviet Union, accounted for over 58% of the World's CFC production.[51] Significant, global emissions reductions

---

preferences and the market rate of interest.

[48] The Montreal Protocol's ten year abolition period implies that it will actually take several decades longer for concentrations to return to their 1985 levels. An additional 8 million tonnes of CFC 11 and 12 will be produced in accordance with the Protocol between 1987 and the final phase-out in 2000 (Thomas 1992: 236).

[49] See Annex I, *Graph I: Proportion of CFC Production by Region, 1984.*

[50] See Russet and Sullivan 1971: 853-856.

[51] See Annex II, *Graph I: Proportion of CFC Production by Region, 1984.*

were possible if just these three countries agreed to reduce emissions. Moreover, since the US accounted for 37% of the World's CFC production, it had both the incentive and the ability to lead the negotiations towards a Protocol that closely accorded with its internal policy objectives.

The concentration of producers and the presence of a leader meant that reductions could be easily monitored and free-riding largely discouraged. Moreover, although the principal protagonists of the Montreal negotiations (the EU and the US) disagreed on most points of debate,[52] ranging from the severity of cuts to the chemical coverage, their shared political, economic and environmental values meant that they approached the negotiations from similar points of view, and with similar attitudes towards risk. Since developing countries were not major CFC producers, they played only a small role in the Montreal negotiations. Few were present at the early meetings and UNEP's Executive Director Mostafa Tolba did not include any in his 'key group'.[53] India and China were not present at all for most of the negotiations, though China did send a single delegate to the final round in Montreal. This greatly simplified the negotiations and eased co-operation. In any event, developing countries received a major concession: the ability to defer compliance for ten years, and to benefit from technical and financial assistance. Many key developing countries signed the protocol immediately, including the semi-industrialised Mexico, Venezuela, Egypt, Kenya, and Thailand, though India and China would not sign until the *London Revisions* in 1990. However, given the fact that in 1987 China and India together only consumed 2% of the world's CFCs and that the United

---

[52] See Benedick 1991a: 76-97.

Kingdom had 90 times the per capita consumption,[54] their accession was not an immediate necessity by any means.

This step-by-step approach of establishing a consensus among the core polluters and then broadening the agreement to include lesser polluters and countries likely to be major future polluters, could not have been taken at the climate change negotiations. A core group of GHG polluters cannot be easily identified; the majority of GHG emissions are caused by the cumulative effect of very small emissions from a very large number of countries.[55] All the developed countries together account for only 55% of global GHG emissions, the remaining 45% comes from the developing countries whose emissions will increase to more than 66% of the global total by 2025. The top three methane producers in 1991, China, Nigeria and India, cumulatively accounted for only 46.3% of total global methane emissions.[56] The top three polluters of industrial-based carbon dioxide in 1991, the US, the EU, and China, together accounted for only 47% of global emissions. Brazil, Indonesia and Zaire were the world's largest contributors of total global carbon dioxide emissions due to deforestation, but together accounted for only 43.6% of world's total. Moreover, no state is among the top three polluters for more than one of the three main GHGs. Chief US ozone negotiator Richard Benedick's comment that, given US leadership on the ozone issue, "The rest of the world expects, and would be responsive to,

---

[53] This 'key group' was a small group of countries that Tolba isolated for intense negotiating sessions whenever the larger group seemed at an impasse.
[54] Thomas 1992: 217.
[55] See Annex II, *Table I: Carbon Dioxide Emissions from Industrial Processes, Table II: Total Methane Emissions from Anthropogenic Sources, Table III: Carbon Dioxide Emissions from Land Use Changes.*
[56] Unless otherwise indicated, the statistics in this paragraph are courteous of the World Resources Institute 1996: < http://data.wri.org:1996/>. Statistical tables are available in Annex I.

similar US leadership on the Greenhouse issue"[57], gives too much credit to American diplomacy; while the US is the World's largest contributor to GHG emissions, it contributes only 19.13% of total World industrial-based carbon dioxide emissions and 10% of the World's methane emissions. Its contribution of carbon dioxide due to deforestation is insignificant.

Unsurprisingly, the high probability of free-riding implied by a large number of polluting countries was only compounded by the fact that the negotiations brought together many countries lacking in shared experiences and a common attitude towards risk. The main protagonists in the Kyoto negotiations were the EU, the Umbrella Group (most non-EU developed countries), and the G-77. The G-77 obviously does not share many of the political, economic, and environmental values of the Umbrella Group and the EU, let alone their political, economic, and environmental agendas. As one negotiator noted,

> Developing countries and developed countries are like two groups of people standing on two different islands shouting at each other. There are no bridges between them... we just don't understand each other.[58]

Developing countries approached the negotiation from the point of view that global warming was a problem caused by developed countries and that these countries were now responsible for its solution. Meanwhile, some developed countries argued that developing countries should take on some kind of commitment for the good of the environment. Essentially, the developed countries were accusing developing countries of free-riding. According to their view, current generations should not be held responsible for the

---

[57] Benedick 1991b: 10.

actions of past generations, though wealthier countries should lead the way simply because they can.[59] The contention has carried over to the ratification process. American ratification of the Kyoto Protocol is in doubt until there is "meaningful participation from key developing countries",[60] particularly from China and India.[61] As Minister Upton notes, "the Prisoners' Dilemma has been left unresolved" by the Kyoto Protocol.[62] The G-77's refusal to take on any commitments may be justified, but it certainly reduces the incentive for the developed countries to take on strong GHG reduction commitments.

VI. Conclusion

The final shape of the Protocols depended on many factors not analysed here, ranging from the influence of scientists and the lobbying of non-governmental organisations, to the guidance of the United Nations Environment Programme, and the personality dynamics of individual negotiators. However, the general strategic dynamics of the negotiations and their results can be explained by abstracting from these political factors and simply examining the incentives implied by the particular attributes of ozone depletion and global warming (see Table II).

---

[58] Kee 1999: Speech.
[59] Grubb 1999: 38.
[60] President Clinton in Barrett 1998: 21.
[61] See Kerry 1997: Interview.
[62] Upton 1999: Interview.

Table II: Comparison of Ozone Depletion and Climate Change

Characteristic	Ozone Depletion	Climate Change
Incentive Structure	Prisoners' Dilemma	Prisoners' Dilemma
Scientific uncertainty of causes	High	Moderate
Scientific uncertainty of effects	Low-Moderate	High
Predicted Damages	High	Very High
Distribution of Abatement Costs and Benefits Between Non-polluters and Polluters	More or Less Even	Uneven (polluters reap a smaller share of benefits than non-polluters)
Distribution of Abatement Costs and Benefits Between Generations	More or Less Even	Uneven (benefits are reaped only in the distant future)
Cost of Controls	Moderate	Very High
Number of Actors	Small	Large
Main Actors	Developed	Developed and Less-developed
Likelihood of Leadership	High (US)	Low

Global warming and ozone depletion are the most similar of environmental problems: both are global in their implications and both require the reduction of noxious emissions. However, the different incentives made it easier and more fruitful to co-operate to reduce CFC emissions, and the Montreal model was not followed in Kyoto.

To hope that the Montreal Protocol and its negotiation will serve as a model for future international environmental co-operation is to hope for too much. If the Kyoto participants are unable to take advantage of the Montreal 'prototype for future environmental co-operation', we cannot expect a success similar to Montreal's from other attempts at international environmental co-operation on topics that have fewer points of similarity and greatly differing incentives.

And it would appear unlikely that the Kyoto Protocol will evolve into a strong GHG emissions abatement regime: scientific uncertainty notwithstanding, the existing strategic relationships are making co-operation impossibly difficult and finding mechanisms to distribute costs more evenly across countries, include developing countries, monitor commitments and punish free-riders is not easy. Moreover, nothing can be done to alleviate the fact that current generations must pay while generations in the distant future will benefit. Barring major technological breakthroughs, it would appear that without very strong evidence of impending catastrophe, and perhaps even then, life on Earth will continue to suffer the risks of largely unimpeded global warming.

Annex I: GHG Reduction Commitments

Table I: Voluntary Reduction Commitments by March 1992.

Country	Gases Included	Action	Base Year	Commitment Year
Australia	NMP GHG	Stabilization	1988	2000
Austria	CO_2	20% Reduction	1988	2000
Canada	CO_2 and other GHG	Stabilisation	1990	2000
Denmark	CO_2	20% Reduction	1988	2005
Finland	CO_2	Stabilisation	1990	2000
France	CO_2	Stabilisation	1990	2000
Germany	CO_2	25% Reduction	1987	2005
Italy	CO_2	20% Reduction	1988	2005
Japan	CO_2	Per capita stabilisation	1990	2000
Luxembourg	CO_2	20% Reduction	89/90	2000
Netherlands	All GHG	20-25% Reduction	89/90	2000
New Zealand	CO_2	20% Reduction	1990	2000
Norway	CO_2	Stabilisation	1989	2000
Spain	CO_2	Limit to 25% Growth	1990	2000
Switzerland	CO_2	At Least Stabilisation	1990	2000
UK (contingent on American action)	CO_2	Stabilisation	1990	2000
US (commitment to set of policies)	All GHG	Stabilisation	1990	2000
EC (target for the Community as a whole)	CO_2	Stabilisation	1990	2000

Note: Many of the targets were provisional or interim targets, some were still pending parliamentary approval in March 1992.
Source: Adapted from IEA, *Climate Change: Policy Update, March 1992*, IEA, Paris, March 1992 and *Guardian*, 1 May 1992 (for the revised UK target) in Paterson in Thomas.

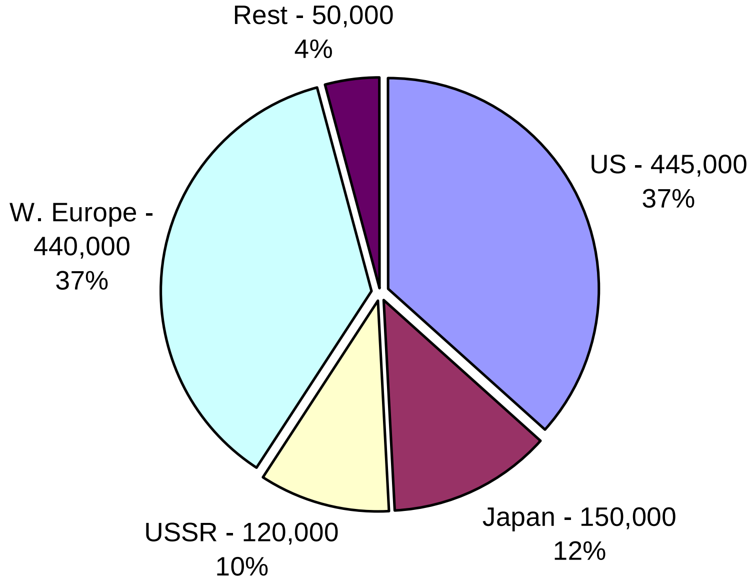
Table II: Kyoto Protocol Commitments

Annex I Countries	Kyoto target 2008-12 (% relative to 1990 or alternative base year)	Projected emissions 2000
United States	93	104
European Union	92	103
Austria	92	111
Belgium	92	n.a.
Denmark	92	103
Finland	92	131
France	92	109
Germany	92	90
Greece	92	115
Ireland	92	120
Italy	92	113
Luxembourg	92	67
Netherlands	92	92
Portugal	92	129
Spain	92	122
Sweden	92	104
UK	92	102
Australia	108	115
Canada	94	110
Iceland	110	105
Japan	94	104
New Zealand	100	116
Norway	101	111
Switzerland	92	97
Liechtenstein	92	118
Monaco	92	n.a.
Economies in Transition	103	81
Alternative base year	98	77
Bulgaria 1990	107	84
1988	92	72
Czech Republic	92	82
Estonia	92	54
Hungary 1990	110	96
1985–7	94	82
Latvia	92	74
Lithuania	92	n.a.
Poland 1990	108	96
1988	94	83
Romania 1990	107	n.a.
1989	92	n.a.
Russian Federation	100	83
Ukraine	100	n.a.
Slovakia	92	84
Croatia	95	n.a.
Slovenia	92	n.a.
Total 1990	95	98
Total base	94	97

Notes: CO_2 emissions exclude land-use change and forestry. Belarus and Turkey are excluded from the table, as they are not included in Annex B of the Kyoto Protocol. Liechtenstein, Monaco, Croatia, and Slovenia are included in Annex B but not in Annex I. All of the countries included in the table are signatories to the Kyoto Protocol. Antigua and Barbuda, Bahamas, El Salvador, Fiji, Maldives, Panama, Trinidad and Tobago, Tuvalu, have ratified the protocol as of April, 1999. *Source*: All data are from the web page of the Climate Change Secretariat, http://www.unfccc.de.

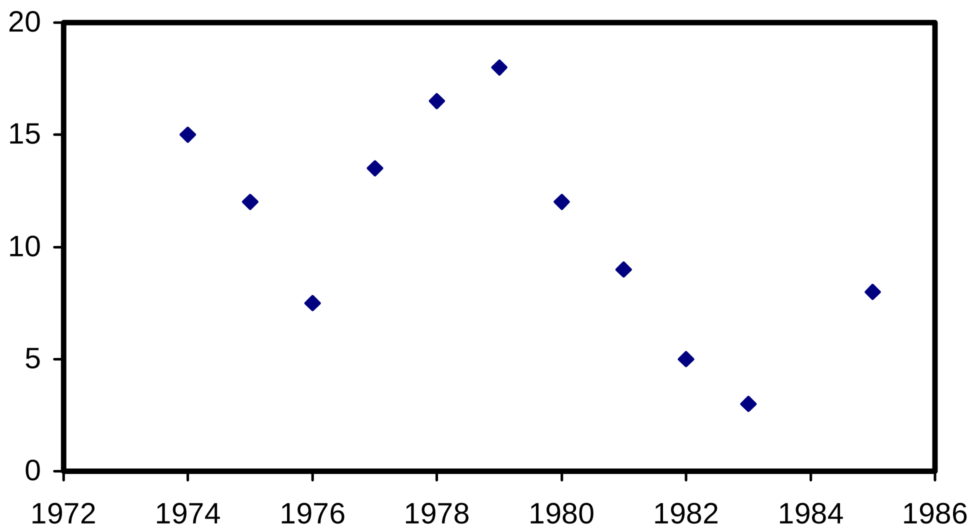
Annex II: Emissions Levels & Effects

Graph I: Proportion of CFC Production by Region, 1984 (tonnes).



Source: Greenpeace, adapted from Thomas 1992: 213
.

Graph II: Various Predictions of the Ozone Depletion, 1974-85



Source: Adapted From National Research Council 1994 and World Meteorological Organisation 1986; in Mathews 1991: 4.

Table I: Carbon Dioxide Emissions From Industrial Processes, 1992

Country	Total CO_2 Emissions (000 metric tons)	Percent of World Total
Canada	409,862	1.8
United Kingdom	566,246	2.5
Ukraine	611,342	2.7
India	769,440	3.4
Germany	878,136	3.9
Japan	1,093,470	4.9
Russian Federation	2,103,132	9.4
China	2,667,982	11.9
European Union	2,981,706	13.3
United States	4,881,349	21.8
World	22,339,408	100

Source: World Resources Institute (http://data.wri.org:1996/), Carbon Dioxide Information Analysis Center and Author's Own Calculations. Notes: Estimates are of the carbon dioxide emitted, 3.664 times the carbon contained. World totals include countries not listed.

Table II: Total Methane Emissions From Anthropogenic Sources, 1991

Country	Total Methane Emissions From Anthropogenic Sources (000 metric tons)	Percent of World Total
VietNam	4,400	1.6%
Australia	4,800	1.7%
Thailand	5,500	2%
Brazil	9,900	3.7%
Indonesia	10,000	3.7%
European Union	15,180	5.6%
United States	27,000	10%
India	33,000	12.2%
Nigeria	45,000	16.7%
China	47,000	17.4%
World	270,000	100%

Source: World Resources Institute (http://data.wri.org:1996/), and Author's Own Calculations. Notes: Estimates are of the carbon dioxide emitted, 3.664 times the carbon contained. World totals include countries not listed.

Table III: Carbon Dioxide Emissions From Land Use Changes, 1991

Country	Carbon Dioxide Emissions From Land Use Change (000 metric tons)	Percent of World Total
Philippines	110,000	2.6%
Myanmar	130,000	3.1%
Bolivia	140,000	3.4%
China	150,000	3.6%
Venezuela	170,000	4%
Malaysia	210,000	5%
Zaire	280,000	6.8%
Indonesia	410,000	10%
Brazil	1,100,000	26.8%
World	4,100,000	100%

Source: World Resources Institute (http://data.wri.org:1996/), and Author's Own Calculations. Notes: Estimates are of the carbon dioxide emitted, 3.664 times the carbon contained. World totals include countries not listed.

Works Cited & Consulted

Barrett, S. "Political Economy of the Kyoto Protocol." Oxford Review of Economic Policy. 14, 4 (1998): 20-39.

Benedick, R. Ozone Diplomacy: New Directions in Safeguarding the Planet. Cambridge: Harvard UP, 1991a.

Benedick, R. "Building on the Vienna Convention: Lessons from 'the Ozone Hole'." in Benedick, R. ed. Greenhouse Warming: Negotiating a Global Regime. Washington: W.R.I. Publications, 1991b.

Benedick, R. "How to Salvage the Kyoto Protocol." Weathervane. (March 1998): <http://www.weathervane.rff.org/pop/>.

Benedick, R. "The UN Approach to Climate Change: Where Has It Gone Wrong?" Weathervane. (December 1997): <http://www.weathervane.rff.org/pop/>.

Bolin, B. Chairman Emeritus, IPCC. "Interview on Science, Politics, and Carbon." Earth Negotiations Bulletin. International Institute for Sustainable Development. RealVideo. (December 3, 1997): <http://www.iisd.ca/linkages/climate/kyoto/coverage.html>.

Brenton, T. The Greening of Machiavelli: The Evolution of International Environmental Politics. London: Earthscan Publications Ltd., 1994.

Bruce, J.P., et al. eds. Climate Change 1995: Economic & Social Dimensions of Climate Change. Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge UP, 1996.

Clinton, W. "Remarks by President Clinton on Global Climate Change a the National Geographic Society, Washington, DC, October 22, 1997." Weathervane. (October 1997): <http://www.weathervane.rff.org/pop/>.

Dorfman, R. & N. Dorfman, eds. Economics of the Environment: Selected Readings. New York: Nortan & Co., 1993.

Drexhage, J. Climate Change International, Associate Director and Canada's Lead Negotiator on Emissions Trading. Interview. April 20, 1999.

Environmental Protection Agency. Assessing the Risks of Trace Gases that Can Modify the Stratosphere. 7 vols. Washington, DC: EPA, 1987b.

Environmental Protection Agency. Protection of Stratospheric Ozone: Proposed Rule. Fed. Reg. 47492. Washington: EPA, 1987a.

Fagerlund, E. Senior Advisor, Ministry of Trade and Industry, Finland. Interview. June 14, 1999.

FCCC/AGBM/1995/4. List of Issues Identified by the Parties. Ad Hoc Group On The Berlin Mandate. Second Session, Geneva, 30 October - 3 November 1995.

FCCC/AGBM/1995/5. Strengthening The Commitments In Article 4.2(A) And (B) Continuing To Advance The Implementation Of Article 4.1: Annotated Compilation Of Information Relevant To The Berlin Mandate Process. Ad Hoc Group On The Berlin Mandate. Second Session, Geneva, 30 October - 3 November 1995.

FCCC/AGBM/1996/10. Synthesis of Proposals by Parties. Ad Hoc Group On The Berlin Mandate. Fifth Session, Geneva, 9-13 December 1996.
FCCC/AGBM/1996/3. Strengthening The Commitments In Article 4.2(A) And (B) Continuing To Advance The Implementation Of Existing Commitments In Article 4.1: Annotated Compilation Of Information Relevant To The Berlin Mandate Process. Ad Hoc Group On The Berlin Mandate. Third Session, Geneva, 5-8 March 1996.
FCCC/AGBM/1996/3. Strengthening The Commitments In Article 4.2(A) And (B) Continuing To Advance The Implementation Of Existing Commitments In Article 4.1: Annotated Compilation Of Information Relevant To The Berlin Mandate Process. Ad Hoc Group On The Berlin Mandate. Third Session, Geneva, 5-8 March 1996.
FCCC/AGBM/1997/2. Framework Compilation of Proposals From Parties for the Elements of a Protocol or Another Legal Instrument. Ad Hoc Group On The Berlin Mandate, Sixth Session, Bonn, 3-7 March 1997.
FCCC/AGBM/1997/2/Add.1. Framework Compilation of Proposals From Parties for the Elements of a Protocol or Another Legal Instrument, Addendum. Ad Hoc Group On The Berlin Mandate, Sixth Session, Bonn, 3-7 March 1997.
FCCC/AGBM/1997/3/Add.1 Report Of The Ad Hoc Group On The Berlin Mandate On The Work Of Its Sixth Session, Bonn, 3-7 March 1997. Ad Hoc Group On The Berlin Mandate, Sixth Session, Bonn, 3-7 March 1997.
FCCC/CP/1995/7/Add.1. Berlin Mandate. 1995.
FCCC/CP/1997/2/Add.1 Adoption of a protocol or another legal instrument: Fulfilment of the Berlin Mandate: Revised Text Under Negotiation, Addendum. Conference of the Parties. Third Session, Kyoto, 1-10 December 1997.
FCCC/CP/1997/L.7/Add.1. Kyoto Protocol to the United Nations Framework Convention on Climate Change. Conference of the Parties. Third Session, Kyoto, 1-10 December 1997.
FCCC/NC/2. Executive Summary Of The National Communication Of New Zealand. 12 June 1995.
Glas, J. “DuPont’s Position Statement on the Chlorofluorocarbon – Ozone – Greenhouse Issues.” Environmental Conservation. 13, 4 (Winter 1986): 363-364.
Grant, C. Deputy Chief Executive, Australian Greenhouse Office. Informal Discussion. June 15, 1999.
Grubb, M. with V. Christiaan & D. Brack. The Kyoto Protocol: A Guide and Assessment. London: Royal Institute of International Affairs, 1999.
Gummer, J. UK Delegate to UNFCCC COP-3. “Interview.” Earth Negotiations Bulletin. International Institute for Sustainable Development. RealVideo. (December 4, 1997): <http://www.iisd.ca/linkages/climate/kyoto/coverage.html>.
Hare, B. Policy Directory, Greenpeace International. Interview. June 30, 1999.
Haas, Peter M. “Banning chlorofluorocarbons: Epistemic Community Efforts to Protect Stratospheric Ozone.” International Organization. 46, 1 (Winter 1992): 187-224.

Hempel, L. Environmental Governance: The Global Challenge. Washington, D.C.: Island Press, 1996.

Houghton, J., et al. eds. Climate Change: The IPCC Scientific Assessment. Cambridge: Cambridge UP, 1990.

Houghton, J., et al. eds. The Science of Climate Change: Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge UP, 1996.

Houghton, J., et al. eds. Climate Change 1994: Radiative Forcing of Climate Change and An Evaluation of the IPCC IS92 Emission Scenarios. Cambridge: Cambridge UP, 1995.

Jachtenfuchs, M. & Strubel, M., eds. Environmental Policy in Europe: Assessment, Challenges and Perspectives. Baden-Baden: Nomos Verglagsgsellschaft, 1992.

Kauffman, J. "Domestic and International Linkages in Global Environmental Politics: A Case-study of the Montreal Protocol." in Schreurs, M.A. and E. Economy, eds. The Internationalization of Environmental Protection. Cambridge: Cambridge UP, 1997.

Kee, Chow Kok. Negotiator, Malaysia, & Chairperson of The Subsidiary Body for Scientific and Technical Advice. Keynote Address. Implementing the Kyoto Protocol. Conference. The Royal Institute of International Affairs. June 14 1999.

Kerry, J. US Senator. "Interview." Earth Negotiations Bulletin. International Institute for Sustainable Development. RealVideo. (December 10, 1997): <http://www.iisd.ca/linkages/climate/kyoto/coverage.html>.

King, P. Australian High Commission. Informal Discussion. June 15, 1999.

Litfin, K.T. Ozone Discourses: Science and Politics in Global Environmental Co-operation. New York: Columbia UP, 1994.

Luna, D. Lead Mexican Delegate to UNFCCC COP-3. "Interview." Earth Negotiations Bulletin. International Institute for Sustainable Development. RealVideo. (December 5, 1997): <http://www.iisd.ca/linkages/climate/kyoto/coverage.html>.

Mathews, Jessica. "Negotiating a Global Regime." in Benedick, R. ed. Greenhouse Warming: Negotiating a Global Regime. Washington: W.R.I. Publications, 1991.

Meyer, A. Union of Concerned Scientists. "Interview." Earth Negotiations Bulletin. International Institute for Sustainable Development. RealVideo. (December 2, 1997): <http://www.iisd.ca/linkages/climate/kyoto/coverage.html>.

Montreal Protocol on Substance That Deplete the Ozone Layer, Final Act. Nairobi: UNEP, 1987.

National Aeronautics and Space Administration (NASA). Executive Summary of the Ozone Trends Panel. NASA, 1988.

Nordhaus, William D. Managing the Global Commons: The Economics of Climate Change. Cambridge: MIT Press, 1994.

Olson, Mancur. "Increasing the Incentives for International Co-operation." International Organization. 25, 4 (Autumn 1971): 866-875.

Rathjens, G. "Energy and Climate Change." in J. Matthews, ed. Preserving the Global Environment: the Challenge of Shared Leadership The American Assembly/World Resources Institute. New York: Norton & Co., 1991.

Roan, S. Ozone Crisis: The 15-Year Evolution of a Sudden Global Emergency. New York: John Wiley & Sons, 1989.

Russet, B. and J. Sullivan. "Collective Goods and International Organization." International Organization. 25, 4 (Autumn 1971): 845-865.

Sandler, Todd. Global Challenges: An Approach to Environmental, Political, and Economic Problems. Cambridge: Cambridge UP, 1997.

Schoeberl, M. and Arlin Krueger. "Overview of the Antarctic Ozone Depletion Issue." Geophysical Research Letters. 15, 8 (November 1986): 1191-1192.

Simms, K. Senior Policy Director, Ozone Action. Interview. April 5, 1999.

Slade, N. "Interview." Earth Negotiations Bulletin. International Institute for Sustainable Development. RealVideo. (December 6, 1997): <http://www.iisd.ca/linkages/climate/kyoto/coverage.html>.

Solow, R. "An Almost Practical Approach to Sustainability." Resources Policy. (Sept., 1993): 162-172.

Stammer, L. "Chinese Delegates to Seek Beijing's Approval for Pact to Protect Ozone; Environment: Move is Hailed as a Breakthrough at U.N. Conference. India's Endorsement is Sought." LA Times. June 29, 1990a: A-8.

Stammer, L. "Ozone Accord Spurs Drive on Global Heating." LA Times. July 2, 1990b A-1.

Thomas, C. The Environment in International Relations. London: The Royal Institute of International Affairs, 1992.

United Nations Environment Program. Report of the Second Meeting of the Parties to the Montreal Protocol on Substances That Deplete the Ozone Layer. UNEP/OzL.Pro.2/3, June 29, 1990.

United Nations Environment Program. UNEP/WG.148/3.

United Nations Framework Convention on Climate Change. UNEP, 1992.

Upton, S. Minister of the Environment, New Zealand. Interview. June 15, 1999.

Vienna Convention for the Protection of the Ozone Layer, Final Act. Nairobi: UNEP, 1985.

Watson, R., et al. eds. Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific and Technical Analysis. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge UP, 1996.

WMO/NASA. Atmospheric Ozone 1985: Assessment of Our Understanding of the Processed Controlling Its Present Distribution and Change. 3 vols. WMO Global Ozone Research and Monitoring Project No. 16. Geneva: WMO, 1985.

World Resources Institute, World Resources: 1996-97. (1999): <http://data.wri.org:1996>.

Young, O.R. International Co-operation: Building Regimes for Natural Resources and the Environment. Ithica: Cornell UP, 1989a.

Young, O.R. "The Politics of International Regime Formation: Managing Natural Resources and the Environment". International Organization. 43, 3 (Summer 1989b): 449

Young, O.R., ed. Global Governance: Drawing Insights from the Environmental Experience. Cambridge: MIT UP, 1997.

Zurer, Pamela. "Complex Mission Set to Probe Origins of Antarctica Ozone Hole." Chemical & Engineering News. (August 17, 1987): 7-13.