Reference: Marc A. Levy (1995), 'International Co-operation to Combat Acid Rain', in Helge Ole Bergesen, Georg Parmann, and Øystein B. Thommessen (eds.), *Green Globe Yearbook of International Co-operation on Environment and Development 1995* (Oxford: Oxford University Press), 59–68.

International Co-operation to Combat Acid Rain

Marc A. Levy

The Nature of the Problem

The combustion of some fossil fuels releases compounds into the atmosphere that are capable of travelling hundreds of miles. When they eventually land they can cause damage to crops, ecosystems, buildings, and human health. This phenomenon has been given the name 'acid rain', because often deposition occurs through mixing with precipitation, and because often the mechanism that does the damage is acidification. But 'acid rain' has come to mean more than acid rain. The label is now used to cover the long-range transport of pollutants (whether or not deposition occurs through precipitation) that cause harm through mechanisms of either acidification or oxidization. The most important pollutants are sulphur dioxide (SO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOCs).

Both acid precipitation and long-range transport of air pollution were known long before acid rain became the subject of international controversy. The Scottish chemist Robert Angus Smith described acid rain as a consequence of high levels of coal burning in nineteenth-century England, publishing his accounts in an 1872 book (that coined the term).[1] And Ibsen wrote of the foul air that travelled across the sea from Britain. But the contemporary understanding of acid rain is of more recent origin. It began in 1967, when Swedish chemist Svante Odén hypothesized that the increasing acidity in Swedish rivers and lakes was attributable to air pollution travelling from continental Europe and Britain.[2] Odén called this 'an insidious chemical war', and warned that it would reduce fish populations, harm forests, increase plant diseases, and damage materials.[3] With scientific acumen and activist zeal, Odén launched the modern acid rain controversy.

Since then the acid rain problem in Europe has gone through three distinct phases—a long period of stalemate, lasting until 1982; a period that witnessed dramatic change in domestic policies, roughly from 1982 to 1988; and finally the current period in which international policies are undergoing significant change.

1968–1982: Stalemate

Between the time of Odén's discovery and 1982 the primary lines of conflict were fixed. On the one side were Sweden and Norway, which recognized serious domestic acid rain damage in lakes and streams, much of it caused by imported sulphur dioxide. On the other side was the entire rest of Europe, which was being blamed for exporting sulphur dioxide. During this period Sweden and Norway attempted, without success, to persuade their neighbours to reduce emissions of SO_2. The rest of Europe had little incentive to comply with these requests. Other countries were free of acid rain damage, as far as they knew, and reducing emissions was bound to be expensive. The persuasive effort continued, however. Sweden highlighted the issue at the 1972 Stockholm Conference on the Human Environment. Sweden and Norway persuaded the Organization of Economic Co-operation and Development (OECD) to carry out studies of the phenomenon, and to issue principles on transboundary air pollution. An important triumph for Scandinavian diplomacy occurred in the mid-1970s, when the unlikely ally of the Soviet Union joined forces to push for a regional convention on acid rain. The Soviets were not concerned about acid rain as an environmental problem, but saw in it a potentially useful vehicle for furthering the *détente* process. In 1979 the Convention on Long Range Transboundary Air Pollution (LRTAP) was signed by thirty-three states, including Canada and the United States.

LRTAP was an important victory for the Scandinavians, but it did not reap immediate benefits. The convention committed parties to broad principles and joint research activities, but not to any concrete measures to reduce acid rain. For the first few years of LRTAP's existence there was little indication that the rest of Europe was going to behave any differently just because a convention had been signed.

1982–1988: Least-Common-Denominator Agreements

But all this changed in 1982, and this year therefore marks the beginning of the second phase of the conflict, lasting approximately up to 1988. In 1982 the German biologist Bernhard Ulrich discovered a new kind of forest sickness, *Waldsterben*, and hypothesized that it was caused by acid rain. Ulrich announced his findings at the 1982 Stockholm Conference on Acidification of the Environment, where German government officials announced they had joined Norway and Sweden in seeking reductions in SO_2 emissions. This was a key turning-point for many reasons. German support guaranteed not only serious SO_2 reductions in a large polluter, it also added a powerful political ally to the Scandinavian cause. Moreover, the discovery that terrestrial ecosystems might be threatened by acid rain drastically altered the geopolitical map. Acid rain was no longer a Scandinavian problem; it was potentially a continent-wide problem.

International co-operation during the second phase entailed two related activities—collaborative science and adversarial diplomacy. The combination of the two resulted in a pair of protocols to the LRTAP convention—a 1985 protocol signed in Helsinki to reduce sulphur emissions, and a 1988 protocol signed in Sofia to freeze emissions of NO_x.

The collaborative science, organized through LRTAP working groups, was important for advancing the state of consensual knowledge about the extent of acid rain damage and about the nature of transboundary flows. The politically most important science was probably that conducted under the auspices of the Working Group on Effects and the European Monitoring and Evaluation Programme (EMEP). The Working Group on Effects oversaw collaborative research on forests, materials, freshwater ecosystems, crops, and integrated monitoring. This research helped solidify a consensus about the importance of the acid rain problem, and in some cases led countries to discover domestic acid rain damage that they had not expected to find. The United Kingdom probably represents the starkest example of this latter phenomenon.

EMEP engaged in highly sophisticated monitoring of pollution flows and modelling of transborder flows. It grew out of early OECD work in the 1970s, when a priority was to determine whether acidifying compounds really did travel long distances. As EMEP grew in sophistication it acquired the capacity to pinpoint with increasing precision the origin and eventual deposition of sulphur dioxide and nitrogen oxides. This furthered the scientific goal of understanding the acid rain problem on a continental scale. It also contributed two key political benefits. First, it established quite clearly who the 'good guys' and 'bad guys' were. And secondly, it created a verification capability that made it almost impossible to cheat on a promise to reduce emissions without getting caught.

The adversarial diplomacy built on the foundation of this collaborative science. Growing knowledge of the severity of the acid rain problem, and of who was responsible for it, helped put pressure on states to reduce emissions. The focal points for this diplomacy were the Sulphur and NO_x Protocols. The Sulphur Protocol asked states to reduce their emissions by 30 per cent by the year 1994, using 1980 as a baseline. Between 1983 and 1985 the number of supporters of the protocol grew from six to twenty-one. High-level meetings in Ottawa and Munich in 1984 helped keep the conversion process going. In the end, the United Kingdom and Poland refused to sign the protocol, as did the United States; but all other significant contributors to the acid rain problem agreed to reduce emissions.

They signed for a variety of reasons. One group, including the Scandinavians, Netherlands, Germany, Switzerland, and Austria did so because of an awareness that acid rain was a serious domestic problem that required multilateral action. Another group calculated that reductions were going to happen anyway, thanks to changing energy policies; this group included France, Belgium, and Italy. Finally, many eastern bloc governments signed for opportunistic reasons, aiming both to keep alive the fruits of their co-operation with Scandinavia and to embarrass the United States and Britain, while never intending to undertake serious reduction measures at home.

The result was a protocol in which not a single signatory planned to use the instrument as a guide to sulphur reductions. The first two groups were able to ignore it because their domestic measures exceeded the required 30 per cent; and the final group intended to cheat fom the beginning. The only exception is the Soviet Union, which probably did take the protocol seriously, owing to its high diplomatic stakes in the convention. This is an exception without a difference, however. The Soviet Union engineered an exception into the protocol permitting it to reduce 'transborder fluxes' instead of total emissions. As a large country it could, therefore, easily comply by shifting some sources to the east (among other ways, by building more nuclear facilities in the west). In most places the prevailing winds push Soviet emissions away from Western Europe, so they were not considered a central part of the political conflict. Again, the exception proves the rule: in the Kola peninsula, where nickel smelters emit enormous quantities of sulphur dioxide that blow across to Norway, emissions have never been reduced.[4]

Following the 1985 Sulphur Protocol, work began almost immediately on a protocol governing NO_x. As with the Sulphur Protocol, a combination of collaborative science and adversarial diplomacy bore fruit in a protocol that was signed in 1988 by twenty-seven states. This protocol required states to freeze NO_x emissions at 1987 levels by 1995. A group of NGOs pressured a group of twelve states to sign a separate, declaratory pledge to go beyond the freeze and reduce by 30 per cent. This pledge was entered into by more states than actually intended to aim seriously for a 30 per-cent reduction. In fact, by the time of the signing of the protocol even some states who signed the protocol itself were in some doubt as to their ability to achieve a freeze.[5] None the less, the NO_x Protocol had in common with the Sulphur Protocol the fact that when initial negotiating positions were formulated prior domestic plans set fixed baselines beyond which governments did not budge.

Both the 1985 Sulphur Protocol and the 1988 NO_x Protocol were therefore variants of 'least-common-denominator' protocols. In neither case did any party sign intending to use the protocol as a guide to revisions in its domestic emission-reduction policies. In fact, there is no evidence that any state (with the possible exception of the Soviet Union) signed any protocol without first determining that already-planned policies would bring it into compliance more or less automatically. (By contrast, the 1987 Montreal Protocol *was* used by most signatories as a guide to alterations in domestic policies.) Analyses of LRTAP that overlook this fact come to the mistaken view that these protocols somehow brought about the reductions in emissions that took place afterwards.[6] On the contrary, it was the change in emission policies that made the protocols possible. It would be misleading, however, to dismiss these protocols as ineffectual. Often least-common-denominator agreements are criticized because they do no more than codify the *status quo*.[7] But under the right conditions they can help advance the *status quo*, and this is what happened in the case of these two protocols. Their power lay not in binding states to undertake measures they otherwise would not (as the Montreal Protocol does), but in helping shift states' perceptions of their self interest.[8]

1989–Present: Creative Problem-Solving

After the 1988 NO_x Protocol LRTAP entered a new phase. Instead of using protocols as instruments of normative persuasion that influence parties during the negotiations but not after signature, negotiators are now seeking to use them as genuine regulatory instruments that impose serious constraints on domestic policies after they are signed.

This shift in the negotiating style reflects an underlying shift in the nature of the acid rain problem in Europe. The most important change has been the conversion of all the important opponents to acid rain controls, with Great Britain's shift in late 1988 being the most dramatic. Once Britain reversed its opposition to acid rain controls, the need for normative persuasion lessened considerably; it became possible for the first time to engage in collective problem-solving around mutual perceptions of the problem.

The exercise in collective problem solving has had two concrete manifestations: the 1991 protocol on volatile organic compounds, and the 1994 revised Sulphur Protocol.

The 1991 VOC Protocol is qualitatively different from the earlier protocols because it commits states to emission-reduction policies that in most cases go beyond what these states had earlier committed themselves to domestically. In fact, most states had no VOC regulations in place prior to the protocol. During the negotiations on sulphur and nitrogen, battle-lines were drawn based on calculations governments had made on the costs of abatement measures and the perceived benefits from reducing acidic deposition; not surprisingly, low cost and high benefit countries favoured steep reductions, and high cost and low benefit countries opposed them.[9] When VOCs were considered, however, the changed atmosphere lent itself to a different mode of interaction. Acrimonious exchanges were largely absent; in fact, disputes over abatement costs and damage estimates were relegated to the sidelines because no government had any reliable estimates of what these were anyway. Instead, debate focused on what sorts of instruments would be most likely to bring about the desired environmental results, and on how variations in national situations could be accommodated most productively. Neither of these debates had a chance during the sulphur or nitrogen negotiations.

This is not to say the tug and pull of politics disappeared. There was a fair degree of suspicion voiced about the Norwegian, Russian, and Canadian proposal to restrict VOC emissions only within designated 'Tropospheric Ozone Management Areas', for example; the idea had technical merit but evoked suspicions that its proponents were trying to escape their fair share of the burden. But such conflicts took a back seat to the mutual search for effective solutions, in stark contrast to the earlier negotiations.

The most dramatic way in which the acid rain problem in Europe has changed is the use of critical loads as a management tool. Critical loads are defined as 'the highest load that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological ecosystems' in a designated area.[10] They are similar to toxicity thresholds. They were seen as overcoming a number of limitations of the use of flat-rate reductions. Flat-rate reductions were inevitably arbitrary from a scientific point of view—there was no ecological basis for settling on a 30 per cent reduction in sulphur emissions or a freeze on nitrogen emissions. Flat-rate reductions also ignored the fact that some countries had undertaken reductions prior to the negotiation of a protocol, while others had not. Perhaps most important, flat-rate reductions overlooked the reality that both sensitivity to pollution and the cost of reducing emissions varied markedly across Europe.

Swedish scientists and government officials were the first actively to promote the use of critical loads as the guiding principle in regulating European acid rain controls.[11] Jan Nilsson was the chief proponent, first arguing in the early 1980s that thresholds should be determined for acidifying compounds and that these thresholds ought to guide policy. A series of LRTAP sponsored workshops formalized a definition of critical loads and began specifying methodologies for measurement and mapping. These workshops enjoyed broad support among government scientists across Europe. Presenting a practically united front, these scientists succeeded in thoroughly transforming the political agenda. The 1988 NO_x Protocol and the 1991 VOC Protocol both contain language specifying that they are only 'first steps' towards later regulations based on critical loads. And the 1994 Sulphur Protocol, which replaces the 1985 instrument, is explicitly based on critical loads.

The use of critical loads was intended to proceed in a series of technical and political activities aimed at deepening the collective regulations in a way that was politically fair and scientifically sound. The most fundamental building-block in this exercise was to be the creation of critical-load maps for Europe. These maps are created by identifying the most sensitive receptor within a given grid, determining the critical load of that receptor using dose–response data, and then aggregating the data onto maps for all of Europe. Methodologies were harmonized and dose–response data were agreed on consensually so that national maps would be readily comparable and integrated.[12]

Vital to this exercise was the RAINS Model, a computerized assessment tool that integrated data on critical loads, transport and emissions data, and reduction cost data to permit negotiators to seek out optimum reduction scenarios and to assess the environmental and economic consequences of alternative regulatory options.[13]

Although the 1994 Sulphur Protocol represents in a way the most complete realization of the critical-loads approach to date, the full effect of critical loads as an organizing principle cannot be grasped by looking only at the protocol. In fact, it is not difficult to evaluate the protocol, narrowly construed, as a return to politics as usual and a failure to realize the promise of critical loads as a means for elevating the science of environmental protection above the politics of expediency.

Such a narrow assessment acquires plausibility (though ultimately falls short) because of the numerous compromises that were required to cement the coalition supporting the protocol. The first concession to political constraints was to focus on 5-percentile critical-load maps, which specify levels of deposition that will protect all but the most sensitive 5 per cent of a grid. This was seen as a necessary concession to political and economic reality, since protecting the most vulnerable 5 per cent of ecosystems would add prohibitively to the cost.[14] However, when the negotiations over the Sulphur Protocol turned to the concept of 'gap closure', politics was appearing to get a double concession. Beginning in late 1993 negotiators started working with a formula by which states would commit themselves to emission targets that would reduce by 60 per cent the gap between 1980 emissions and emission levels needed to achieve critical loads. Because the gap closure was measured against the critical loads baseline, and critical loads were already calculated on a 5-percentile basis (that is, they already had a gap built in), to some observers the shift in the debate to gap closure was giving away the same concession a second time, this time on an even bigger scale. When, in early 1994, the focus shifted from 60 per-cent gap closure to 50 per-cent gap closure, the concession looked bigger still.

As other deviations from the original model became necessary for political reasons, the accumulated effect was to cast the exercise into some disrepute. Some governments sought permission to use alternatives to RAINS in calculating the emission reductions needed to achieve a particular level of gap closure. Some governments sought to use a different base year for use in calculating percentage reductions, and some sought to set later target years than others. As these deviations from the initial idea behind critical loads accumulated it soon became evident that what was happening was that states were finding ways to couch their commitments in such a way that they required no further action beyond what they had already planned domestically. The new sulphur protocol, so radically new in its original design, was ending up having a lot in common with the old.

Table 1. Obligations under the 1994 Sulphur Protocol (as % reduction in 1980 emissions)

	Target Year		
	2000	2005	2010
Austria	80		
Belarus	38	46	50
Belgium	70	72	74
Bulgaria	33	40	45
Canada (national)	30		
Canada (SOMA)*	46		
Croatia	11	17	22
Czech Republic	50	60	72
Denmark	80		
Finland	80		
France	74	77	78
Germany	83	87	
Greece **	0	3	4
Hungary	45	50	60
Ireland	30		
Italy	65	73	
Liechtenstein	75		
Luxembourg	58		
Netherlands	77		
Norway	76		
Poland	37	47	66
Portugal **	0	3	
Russian Federation	38	40	40
Slovakia	60	65	72
Slovenia	45	60	70
Spain	35		
Sweden	80		
Switzerland	52		
Ukraine	40		
United Kingdom	50	70	80
European Community	62		

Note: * SOMA = Sulphur Oxide Management Area, an area designated for different levels of reductions.

** Greece and Portugal are actually permitted to increase emissions against their 1980 baselines, by 48% and 14% respectively. The text of the protocol avoids singling them out in this way by using their emission ceilings for the year 2000 as the basis for reduction targets. Formally, each country's commitments are specified in terms of emission ceilings, not percentage reductions.

Source: *Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Further Reduction of Sulphur Emissions.*

Between mid-1993 and early 1994, for example, one witnessed almost the mirror image of the ground-swell of support that culminated in the signing of the first Sulphur Protocol. Instead of states rushing to jump on the 30 per-cent club bandwagon, this time they were rushing to jump off the critical-loads bandwagon, at least as it was originally designed. Even under the less ambitious 50 per-cent gap-closure target, the United Kingdom, Belgium, Denmark, France, Ireland, and Spain all sought weaker reduction targets, pitting themselves against a coalition of Sweden, Norway, Finland, Germany, the Netherlands, Austria, and Switzerland.[15] As this conflict emerged, the politics came to resemble, on the surface at least, those of a decade ago. Swedish and Norwegian officials branded the United Kingdom an irresponsible renegade guilty of damaging Scandinavian resources. In one heated moment Norwegian environment minister Thorbjørn Berntsen publicly called his British counterpart, John Gummer, a shitbag.[16]

As the political conflict heightened, this protocol that was supposed to rationalize the management of acid rain seemed to be having an altogether different effect. For the editorial board at the *Energy Economist*, it had become 'self-consciously pointless', and 'a humiliating blow to the scientific effort that has underpinned the running of the protocol. The reply delivered to the scientists has been: "No, you are wrong, there is no role for science in international negotiations, we are going to ignore you, you might as well not have bothered to carry out this work".'[17]

This pessimistic view is just as wrong as the rosy assessments of the 1985 Sulphur Protocol that give that instrument credit for all the sulphur reductions that took place over the 1980s. It is true that the protocol commits states no further than they had already planned to go domestically. And it is true that during the final months of negotiating there was only a very weak role for science in the political deliberations. But although intense political negotiations are the stuff of great drama (anything that can prompt a Norwegian minister to lose his temper in public qualifies as drama), in the overall course of things they are far from the most important phenomena. An accurate evaluation of the use of critical loads in the LRTAP process requires an assessment of the difference that critical loads made in the course of preparatory work leading up to the 1994 Sulphur Protocol as well as in the protocol itself.

On these grounds the effort looks more effective. The most fundamental effect that critical loads had was to shift the nature of the public debate, both internationally and in many domestic settings, away from determining who the bad guys were, and towards determining how vulnerable each party was to acid rain. The case of Britain is the best illustration of this phenomenon. Before the critical-loads approach Britain spent most of its time within LRTAP trying to defend its refusal to go along with the activist states' demands to reduce sulphur and nitrogen emissions.[18] After the critical-loads approach was adopted Britain threw itself heartily into the exercise and quickly emerged as an intellectual and entrepreneurial leader in the effort, along with the Dutch, Swedes, and Norwegians. The effect of the switch was so profound that a British government scientist, Robert Wilson, was appointed chairman of the Working Group on Effects, which oversees the critical-loads mapping efforts.

Within Britain as well critical loads thoroughly transformed the debate. Instead of a bruising stalemate between hard-line Thatcherite conservatives and Labour, Liberal Democrats, and a few wet Tories, which dominated the early 1980s, Britain went about the technical and uncontroversial work of mapping critical loads. As this work progressed it became evident that one of the unquestioned assumptions of British acid rain policy—that while the United Kingdom might or might not be responsible for acidification abroad, at least it had no domestic acid rain problem to worry about—was simply false. The British critical-load maps revealed a sizable swathe of highly vulnerable ecosystems in Scotland and Wales, as well as other sensitive areas. The constituency supporting acid rain controls expanded from environmental activists and élites concerned about the standing of Britain abroad to include those worried about the fate of the British countryside—a much larger group.

Whereas Britain had fought very hard against a European Community directive on sulphur and nitrogen emissions from large combustion plants, eventually signed in 1988, in 1990 it committed itself in principle to adopting even stricter emission-reduction standards based on critical loads.[19] By 1993, when the new protocol was negotiated, Britain was voluntarily pursuing policies aimed at reductions on the order of 70 per cent.

A 11 March 1994 headline in the *Financial Times* reflects how deeply the British debate had shifted. Whereas a decade earlier the focus had been on whether or not Britain was wrongfully polluting its neighbours, now the focus was on a report showing that 'Half of Country "is Damaged by Acid Rain"'.[20]

Other factors were pushing Britain in a more green direction, so critical loads and LRTAP cannot claim all the credit for the change in British acid rain policies. Beginning in 1988 the British government underwent a transformation away from obstructionism on international environmental issues towards a more activist bent; this transformation was realized in a number of issues beyond acid rain, including ozone depletion, climate change, and biodiversity. In addition, much of the power sector was privatized, which had the twin beneficial effects of dispersing the political power which had formally rested in the Central Electricity Generating Board, and especially, of freeing the power generators to switch fuels away from coal, which was politically popular, and towards gas, which was economically sensible. Because gas produces radically less sulphur than coal, privatization deserves a sizable amount of the credit for British sulphurreductions.

The impact of critical loads on Britain, the above exogenous factors notwithstanding, are highly important because of Britain's contribution to European air pollution. It has the third highest emission levels, and contributes a significant percentage of the deposition in Sweden and Norway, two of Europe's most vulnerable countries. Any solution to the European acid rain problem will require active British co-operation, yet until the last few years this appeared an elusive goal.

The critical-loads concept has influenced other countries as well. Among the governments that incorporate critical loads into their domestic acid rain policies are Austria, Denmark, Finland, France, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, and Russia.[21] The Netherlands, for example, was one of the first governments to embrace critical loads as a guiding tool for domestic policy. This caused a shift in emphasis away from specific pollutants and towards vulnerable ecosystems, which were found to be seriously endangered. This in turn led to a steady ratcheting downwards of the target deposition loads, and a search for broader sources of acidifying compounds that could be reduced. This last task resulted in a series of measures aimed at reducing ammonia emissions from livestock—this innovation would likely not have occurred without the impetus of critical loads.[22]

LRTAP as a Qualified Success

A number of characteristics of the evolution described above warrant the characterization of LRTAP as a success.

One clear success was the ability to shift from rigid, positional disputes to collective problem-solving. The early years of the acid rain problem were dominated by efforts to assign and deflect blame. Since the late 1980s blaming has declined in salience (perhaps not disappearing entirely), giving way to a broad-based collective search for mutually beneficial solutions to shared problems. Whether in personal life or international politics this is not an easy transformation to bring about, and it is a sign of great success that it happened in this case.

A related aspect of LRTAP's success was that this shift to collective problem-solving occurred in a political environment characterized by a deep ideological divide. The East–West conflict in which LRTAP operated (indeed, to which LRTAP owes its existence) never seriously undermined the effectiveness of the convention. In fact, LRTAP had a significant effect in helping to build up scientific and technical capacity for assessing acidification problems in Eastern Europe and the Soviet Union.[23]

Another clear success is the way LRTAP has helped broaden the scope of action as understanding of the acid rain problem has expanded. Instead of getting stuck in initial ideas about how best to respond to the acid rain problem, LRTAP has proved quite flexible at adding NO_x and VOCs to its agenda, and now has even started investigating such far afield issues as heavy metals and complex organic compounds.

Finally, LRTAP has had a significant effect in the emergence of a number of transnational networks that play important roles in the management of the acid rain issue. It serves as the focal point for a dense scientific network that links acid rain researchers across North America, Scandinavia, Eastern Europe, Russia, and EC members. It has helped form looser networks among environmental activists.

What accounts for these successes? Managing international environmental problems is a complex task, with numerous factors interacting to produce results that are difficult to evaluate. Some success is really just luck, some apparent failures are really successes at keeping things from getting worse. With those cautions in mind, it is possible to identify some factors where more than luck was involved.

First, LRTAP defined its task consistently in terms of environmental impacts rather than particular causes of the problem. In practical terms this meant organizing scientific working groups around identifying and understanding phenomena such as lake acidity, forest health, materials damage, and so on, rather than strictly around various methods for responding to these problems. LRTAP does organize working groups around specific pollutants in connection with the negotiation of protocols, but these are transient and given specific, pragmatic tasks. It is the effects-oriented groups that endure.[24]

Secondly, the LRTAP process integrated knowledge-building exercises artfully with the task of negotiating international regulations. In the initial years it used regulatory protocols as vehicles for focusing public attention, for embarrassing laggards, and for building transnational alliances. These uses of the protocol made use of the underlying scientific exercises, and at the same time added to the momentum that kept these scientific efforts thriving.

Obstacles to Effective International Solutions

The effort to cope with acid rain is far from an unqualified success, and we may learn from the shortcomings of international efforts as much as from their victories. In contrast to the successes, which centre around the way people see the problem, the failings all centre around the actions people take.

Weak Transnational Action-oriented Networks

One clear failure is that, in contrast to the tight integration and transnational links that LRTAP has helped promote around awareness and understanding of the problem, it has contributed very little to such links around the issue of implementing strategies for managing the acid rain problem. There is scarcely any collaborative research and development on technological options for reducing emissions. In fact, on technological issues conflict remains much more openly combative than it is on questions of impacts. Unlike the Montreal Protocol, LRTAP has consistently failed to spark any reassessments of technical or economic constraints within domestic constituencies. Although LRTAP has helped tremendously to solidify a thriving network of scientists and activists seeking action, it leaves them to their own devices to convince domestic opponents who argue that reduction measures are too costly.

LRTAP faces considerable difficulty correcting this failure. Many of the most important industrial sectors are under government control and have weak transnational connections. This is the case for the two biggest polluting sectors, power generation and transportation. In other environmental problems, where the economic sectors are private and have extensive transnational links, technical knowledge diffuses more readily. Multinational corporations competing with each other for a share of the global market, for example, are more inclined to experiment with new technology in case it presents competitive advantages than are firms that do not face competition. The power industry in Europe (as in the world at large) is dominated by quasi-monopolistic, state-protected firms. The auto industry has similar constraints on a somewhat smaller scale. Many firms are protected or partially owned by their home governments, limiting their incentives to assess pollution control technology realistically.

A long-term, effective solution to the acid rain problem will require replicating the dense transnational network that exists with regard to awareness and understanding in the realm of action. The so-far elusive goal of a single European energy market would be a great help in this regard.

Little Attention Paid to Coping with Impacts

Another failing is the lack of creative attention to coping with the impacts of acidification as opposed to taking only the preventive measure of reducing emissions. At the domestic level the Scandinavians engage in a significant amount of liming of lakes and soils to help cope with the effects of increasing acidic deposition. Where drinking water supplies are highly acidic, water authorities often add buffering agents to prevent harmful effects to human health. LRTAP has done practically nothing to share expertise and knowledge on how these adaptive measures work and where they might currently be under-supplied. In a prospective vein, it is now clear that emissions of ground-level ozone precursors are going to increase in Europe into the near future. This means that stresses on human health and agricultural crops will increase. An effective international response to this problem calls for sharing of information and strategies, and perhaps for joint exploration of new strategies, around the issue of coping with these impacts.

There is strong resistance, however, to addressing the need to cope with impacts at the international level. As one Swedish official put it: 'We considered doing that, but decided it would reduce the pressure to cut emissions.'[25] But in the absence of reliable assurances that current adaptive measures are adequate, especially in the former eastern bloc countries with poor historical records on these matters, this argument is irresponsible.

No Mechanism for Financial Transfers

One of the biggest failures of LRTAP has been its inability to contribute to any significant transfer of financial resources from west to east. Although it has been realized since the early 1980s that some of the most severely affected countries (such as Sweden) could achieve reduced deposition at far lower cost if they could find a way to finance emission reductions in poor, highly polluting countries (such as Poland), very little practical progress was made towards putting this idea into practice. To be sure, there were some good reasons for treading lightly in these waters before the changes of 1989. Some carefully conducted experiments at linking financial assistance and emission reductions might have generated significant benefits, however, and they ought to have been tried. Such experiments might have helped avoid some of the floundering and squandering that occurred with East–West environmental assistance in the immediate years after the changes of 1989.[26] They might have helped integrate Eastern Europe, Russia, and the former Soviet Republics more directly into the negotiation of the 1994 Sulphur Protocol, instead of shunting them once again on to the margins, forced to hope for either a continued recession or a technological miracle to bring them into compliance with their commitments. For so much of the LRTAP agenda to be taken up over 1993 and 1994 with debates over whether the United Kingdom should reduce 76 per cent or 80 per cent (and similar matters), while so little was devoted to discussing such matters as how to help Poland and the Czech Republic finance the measures needed to implement their targets, is almost farcical.

In any event, there is now a widespread consensus that, regardless of whether early action was possible, now is the time to pursue the matter vigorously. The Working Group on Strategies within LRTAP has been directing attention to this issue since 1992, mainly by way of commissioning studies evaluating the prospects for competing cost-sharing mechanisms. One possibility is to create an 'acidification fund' within LRTAP, which would be used to finance emission-abatement projects.[27] Wealthy countries would pay into the fund and poor countries take from it. Another option is to permit joint implementation, in which a wealthy country would meet its own reduction commitment, in part, by financing reductions elsewhere.[28] Finally, a third option that has been examined is a tradable permits scheme.[29] Countries could meet their reduction targets through a combination of reduction measures and purchase of permits from abroad.

The discussion within the Working Group on Strategies, at least as reflected in the papers it has commissioned, has some way to go before workable ideas will emerge. Some of the ideas are politically naïve. Why, for example, would all the wealthy LRTAP signatories contribute to an acid abatement fund when many (such as the United Kingdom and France) stand to gain almost nothing in return? All the ideas are weak on the institutional infrastructure required to support the transfer schemes. There is almost no discussion of how compliance with the terms of financial transfer will be guaranteed, for example, nor of how the value of tradeable permits will be safeguarded (what happens if A buys a permit from B, but B emits anyway?). The Protocol makes oblique reference to joint implementation in Article 2, section 6, but leaves it to future decisions by the Executive Body to determine under which conditions it will be permitted.

These are not insurmountable problems; indeed, they are faced to one degree or another in every environmental financial transfer. But they require politically feasible solutions arrived at through joint deliberation. LRTAP signatories have not yet begun those deliberations.

Should LRTAP fail to develop a financial transfer scheme, the fall-back option is to rely on the current mix of financing measures under way: a combination of loans and grants from multilateral banks and bilateral aid agencies. These programmes suffer the disadvantage of having no formal link to LRTAP, and therefore being unable to exploit either joint implementation possibilities or to make direct use of compliance incentives. They have the advantage, however, of being part of a broader effort to co-ordinate the economic restructuring of the region; that might give them a greater long-term chance of success.

Fragile Compliance Procedures

Finally, LRTAP is poised to cross a threshold in how it treats questions of compliance. If it crosses that threshold successfully, a range of new opportunities will be available; if it ails, many promising ideas will be threatened. The threshold presents itself by virtue of the heightened attention given to compliance questions during the negotiation of the 1994 Sulphur Protocol. With earlier protocols, which simply codified the *status quo*, compliance issues were never highly salient; the only states that cheated were states that everyone thought would cheat from the beginning. But because the 1994 Protocol was intended to be different, to go beyond the *status quo*, compliance was given much more serious attention.

Article 7 of the Protocol represents the result of that increased attention. It establishes an 'Implementation Committee' to review implementation and compliance by parties. It is to report to the Executive Body with recommendations, which may then 'call for action to bring about full compliance with the present Protocol, including measures to assist a Party's compliance with the Protocol, and to further the objectives of the Protocol'.

This may sound timid, but it signals a break with the past, when instances of non-compliance and lack of implementation were treated very lightly. The unwritten rule in the past was not to embarrass states by bringing their failures out into the open. In practice, even such a simple procedure as taking note of implementation and compliance failures and developing corrective courses of action might make a big difference.

The way the article is written, there is nothing to guarantee that it will make a difference; it might prove just as timid in practice as prior protocols were. Success will require energetic and creative procedures that will be a departure for LRTAP. Useful models are to be found in the OECD, IMF, and GATT performance reviews.[30]

Future Prospects

A New NOx Protocol?

Sulphur is the easiest compound LRTAP has to worry about. Its effects are well understood and most of its emissions can be controlled by regulating a single activity (power generation). Nitrogen is tougher, both because its effects are more complicated and therefore less well understood, and because its sources include power generation plus transportation. That is one reason the activist countries were forced to abandon their initial hopes for a 30 per-cent reduction protocol for NO_x, and why some of those activist countries are having a difficult time meeting their commitments.[31] A new NO_x protocol, to replace the current one which lapses in 1996, will be much tougher to negotiate than the second sulphur protocol.

Some analysts are arguing that instead of a second NO_x protocol, LRTAP ought to combine NO_x and VOCs and negotiate new regulations for both classes of compounds in a single protocol. The argument is that, because NO_x and

VOCs are both precursors of ground-level ozone, there is no way to negotiate a protocol based on critical loads that does not incorporate both classes of compounds. The problem this presents is that VOCs are easily an order of magnitude more complicated, on both chemical and political grounds, than NO_x.[32] To regulate both at once may significantly slow down progress on a revised NO_x regulation.

Substantive Links to North America

The United States and Canada are signatories to LRTAP because they were caught with Western Europe in the same diplomatic net thrown by the Scandinavian–Soviet initiative in the 1970s. No one in Europe ever really considered North American emissions to be a European problem, however, nor vice versa. Now, though, as European emissions fall and transport modelling becomes more sophisticated, there is emerging a real, substantive reason for integrating North American and European acid rain policies.

The advantages of such integration lie in the long run. Although current depositions in Europe of North American emissions are quite small, these will increase in importance if Europe continues to reduce; if the goal of meeting critical loads is taken seriously, then every last percentile of deposition makes a difference. In addition, LRTAP is beginning to cast an eye toward regulating emissions of complex organic compounds, toxic chemicals that travel very long distances. Regulation of complex organic compounds, on scientific grounds, ought to involve both North America and Europe, because their emissions travel into each-others' territories.

However, the principal difficulty is that the United States bases its air pollution regulations on technical standards, not environmental quality standards. It will, therefore, be reluctant to commit itself to international instruments cast in terms that are incompatible with its domestic regulatory apparatus.

Acid Rain Outside Europe and North America

In 1980 Europe and North America accounted for approximately 62 per cent of the global sulphur emissions. It is precisely because emissions were concentrated in this relatively small geographic area that the acid rain problem emerged there first. But like most environmental problems associated with industrialization, acid rain is destined to spread. Growing population and per-capita fossil fuel use mean that acid rain problems are likely to emerge in Latin America, Africa, and especially Asia, where sulphur emissions are projected to exceed total European and North American emissions by 2010.[33]

General awareness of potential acid rain problems outside Europe and North America is mainly low, however. The clearest exception is in Japan, where concern over the possibility that Chinese emissions may pose an environmental threat is growing. But relatively low geological sensitivities in Japan make it unlikely that it will be the next country to experience serious damage. An explicit effort to transfer some of the European experience to Asia more broadly, in anticipation of acid rain problems there, is now under way, with funding from the World Bank and the Asian Development Bank. One intended product of this effort is a RAINS-ASIA model, similar to the RAINS model that has played an important role in Europe.

For those who are serious about reducing the scale of acidification-induced damage in Asia and elsewhere in the developing world, equal attention ought to be paid to the challenge of transferring financial and technological resources where they can most effectively be used. Even if the RAINS model is exported completely successfully, effective responses will not be forthcoming in the absence of creative solutions to the problems that continue to plague East–West relations in Europe. Particular attention will need to be paid to efforts to organize the mobilization, transfer, and control of financial resources; to efforts to transfer proven technologies in the power-generation and transport sectors; and to efforts to uncover novel strategies suited to local circumstances. Each of these problems is currently stalling efforts to reduce emissions of acidifying compounds in Eastern Europe, some twenty-six years after they were identified as a problem. Any forward-looking strategy aimed beyond Europe ought to place these problems, however difficult they may be, front and centre.

Notes and References

1. Ellis Cowling (1982), 'Acid Precipitation in Historical Perspective', *Environmental Science and Technology*, 16 (Feb.), 111A.
2. Svante Odén (1968), 'The Acidification of Air and Precipitation and its Consequences in the Natural Environment', *Ecology Committee Bulletin Number 1*, Swedish National Science Research Council (Stockholm). This is the first scientific publication with Odén's results, though Odén had made his results known in the press in 1967. I am grateful to Ellis Cowling for conversations on Odén and his work.
3. Cowling, 'Acid Precipitation' (n. 1 above), 114A–115A.
4. Rune Castberg (1993), 'Common Problem—Different Priorities: Nordic–Russian Environmental Cooperation and the Nickel Works of the Kola Peninsula', *International Challenges*, 13: 3, 23–33.
5. I am grateful to Jørgen Wettestad for clarifying this to me.
6. Amy A. Fraenkel (1989), 'The Convention on Long-Range Transboundary Air Pollution: Meeting the Challenge of International Cooperation', *Harvard International Law Journal*, 30: 2 (Spring), 471.
7. Lawrence Susskind (1994), *Environmental Diplomacy: Negotiating More Effective Global Agreements* (Oxford University Press, New York).
8. Marc A. Levy (1993), 'European Acid Rain: The Power of Tote-Board Diplomacy', in Robert O. Keohane, Peter M. Haas, and Marc A. Levy (eds.), *Institutions for the Earth: Sources of Effective International Environmental Protection* (Cambridge, Mass.: MIT Press).

9. Detlef Sprinz and Tapani Vaahtoranta (1994), 'The Interest-based Explanation of International Environmental Policy', *International Organization*, 48: 1 (Winter), 77–105.
10. Jan Nilsson, (ed.) (1986), *Critical Loads for Sulphur and Nitrogen: Report from a Nordic Working Group*, National Swedish Environment Protection Board, Solna.
11. I am grateful to William F. Dietrich for discussion on the spread of critical loads.
12. Juha Kämäri, *et al.* (1992), 'The Use of Critical Loads for the Assessment of Future Alternatives to Acidification', *Ambio*, 21: 5 (Aug.), 377–86.
13. Leen Hordijk (1991), 'Use of the RAINS Model in Acid Rain Negotiations in Europe', *Environmental Science and Technology*, 25: 4, 596–602; Joseph Alcamo, Roderick Shaw, and Leen Hordijk (eds.) (1990), *The Rains Model of Acidification: Science and Strategies in Europe* (Kluwer, Dordrecht).
14. According to the RAINS model, the cost of protecting the 96th through 98th percentiles costs the same as the entire first 95, while the last 2 per cent cannot be protected at any cost. *Energy Economist* (Nov. 1993).
15. *Financial Times*, 5 Nov. 1993, 'Power Europe' section.
16. *Independent*, 18 Sept. 1993, p. 9. Berntsen used the Norwegian term *drittsekk*, which is slightly (but only slightly) less offensive than its English equivalent. The two ministers later were reconciled at an EC Council of Ministers meeting.
17. *Energy Economist*, Nov. 1993.
18. Typical in this regard is 'UN ECE Convention on Long-Range Transboundary Air Pollution, Review of Strategies and Policies of the Contracting Parties to the Convention, United Kingdom Response', n.d. (1986), typescript, 13 pp.
19. 'This Common Inheritance: Britain's Environmental Strategy', Cm 1200 (London: HMSO, Sept. 1990), 149.
20. *Financial Times*, 11 Mar. 1994, p. 10; citing 'Critical Loads of Acidity in the United Kingdom', Department of the Environment, 1994.
21. EB.AIR/WG.5/R.24/Rev.1 (1991).
22. I am grateful to Gerda Dinkelman for sharing information on Dutch acid rain policy with me.
23. For such an argument, see Marc A. Levy, 'East–West Environmental Politics After 1989', in Stanley Hoffmann, Robert Keohane, and Joseph Nye (eds.) (1993), *After the Cold War: International Institutions and State Strategies in Europe, 1989–1991* (Cambridge, Mass,: Harvard University Press).
24. By contrast, the International Maritime Organization organizes its work around such specific response options as tanker regulations, safety standards, and oil reception facilities; as a result the IMO has contributed quite little to understanding of the marine oil pollution problem.
25. Confidential interview with Swedish acid rain official, Uppsala, 19 Aug. 1994.
26. For more details on the problems with the initial rush of environmental assistance, see Levy, 'East–West Environmental Politics After 1989' (n. 23 above).
27. Options for organizing such a fund are analysed in Johan Sliggers and Ger Klaasen, 'Cost Sharing for the Abatement of Acidification in Europe: The Missing Link in the Sulphur Protocol', paper prepared for Working Group on Strategies, Executive Body for the Convention on Long Range Transboundary Air Pollution, 1993.
28. This option is reviewed in Paul Ruyssenaars, Johan Sliggers, and Henk Merkus, 'Joint Implementation in the Context of Acidification Abatement', paper prepared for Working Group on Strategies, Executive Body for the Convention on Long Range Transboundary Air Pollution, 1993.
29. Ger Klaasen, 'Trade Offs in Exchange Rate Trading for Sulfur Emissions in Europe', paper prepared for Working Group on Strategies, Executive Body for the Convention on Long Range Transboundary Air Pollution, 1993.
30. See Abram Chayes and Antonia Handler Chayes (1995), 'The New Sovereignty: Compliance with Treaties in International Regulatory Regimes' (Cambridge, Mass.: Harvard University Press).
31. See e.g. Per Elvingson, (1994), 'Nitrogen Oxides: Norway Gives Up', *Acid News*, 2 (Apr.), 3.
32. Hundreds of compounds qualify as VOCs, and they are emitted in a wide range of industrial activity. Their life-span in the atmosphere, the distances they travel, and the amount of ozone they are responsible for are all the subject of ongoing scientific controversy.
33. D. M. Whelpdale (1992), 'An Overview of the Atmospheric Sulphur Cycle', in R. W. Howarth, J. W. B. Stewart, and M. V. Ivanov (eds.), *Sulphur Cycling on the Continents*, SCOPE (London: John Wiley & Sons), 5–26.