Multi-lateral emission trading: Lessons from inter-state NO_X pollution

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Abstract:

Marketable permit schemes are often proposed as efficient means of managing CO2 emissions in order to combat global climate change. This paper presents the basis of such claims and discusses some of the problems with them. One of the principal problems is that there will be far more heterogeneity in any international marketable emissions permit system than in the centrally-imposed systems seen so far and often held up as examples. The best examples of how such a multi-lateral marketable emissions permit schemes may or may not emerge in the international setting come from the successful and (so far) failed efforts to create inter-State markets for the control of nitrogen oxides (NO_X) in the eastern U.S. The paper will focus on the distinctive lessons for these examples offer for potential implementation of CO_2 emissions trading and how the literature on Common Property Resources illuminates these lessons.

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1 Introduction

Marketable emissions allowance systems have proposed as efficient means of managing emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs) to control global climate change. In this paper, we examine some examples of air pollution emissions trading and derive lessons from them. The U.S. Acid Rain Program to control SO_2 emissions from power plants is often held up as an example for international CO_2 control efforts (Solomon 1995; Solomon 1999; Stavins 1997). However, there are serious limitations to this example (Fort and Faur 1997; Victor 1991). One of the most important limitation is that the SO_2 program is a domestic effort put in place through the action of a national legislature, which has no parallel in international politics. Any international marketable emissions permit scheme will have to be the product of an agreement by sovereign nations, not imposed by a single authoritative government. Thus, the actors involved will be much more heterogeneous than those involved in the SO_2 program, which may limit the applicability of many lessons derived from it.

The atmosphere and the rest of the climate system are a common property resource (CPR), which suggests that their management may be problematic. A particularly difficult issue is the heterogeneity of the principal actors, as indicated above. The literature on CPR dilemmas is fairly large (see (Ostrom, Burger et al. 1999) for a review), but only recently has the issue of heterogeneity among the actors in CPR disputes been discussed in any detail (Connolly 1999; Hackett 1992; Mitchell 1999; Schlager and Blomquist 1998). Several relevant ideas have been generated in prior research. First, the position of each actor with respect to the resource itself and on other dimensions can vary significantly, some participants being advantaged and some disadvantaged. Schlager and Blomquist (1998) give hypothetical examples of institutionally-differentiated actors and deduce the outcomes, but present no examples. Below we show two examples that bear out the theoretical predictions. Second, Mitchell (1999) shows that for a variety of reasons CPR dilemmas are likely to be more common and more difficult to manage in the international domain than in the domestic. In our cases, similar results are observed in inter-state disputes within a federal system. Third, Connolly (1999) shows that an important feature of negotiations about common resources is how the perception of self-interest can change whether an actor favors developing CPR use or not.

The best examples of how such a multi-lateral marketable emissions permit schemes may or may not emerge in the heterogeneous international setting come from the inter-State markets for the control of nitrogen oxides (NO_X) in the eastern U.S. These programs, designed to combat smog in the eastern part of the country include one successful example, the OTC NO_X Budget, and one highly troubled example, the NO_X SIP Call (Farrell, Carter et al. 1999; U.S. Environmental Protection Agency 1997). These examples are very similar to one another, but differ substantially from the well-known SO_2 example, including greater heterogeneity and competition among resource users (i.e. polluters) and a more difficult technical challenge, as well as the multi-jurisdictional issue.

Finally, we should note that in the conceptual framework laid out by Schlager and Ostrom (1992), we are interested in the constitutional level of action, in which the methods to devise collective choice rules are decided upon, but not the rules themselves. In particular, we are interested in how different jurisdictions can agree to create and govern an international emissions trading system, but not whether nations or firms should be participants in that system.

1.1 Emissions Trading

Several types of marketable emissions trading systems exist. We will focus only on the "Cap-And-Trade" variety because the most successful examples in the U.S. (where almost all emissions trading experience has been gained) are of this sort (Farrell 2000; Klier, Mattoon et al. 1997; Stavins 1997). In Cap-And-Trade programs, regulated firms are allocated a fixed number of allowances and are required to redeem one allowance for every ton of pollution emitted.[*] The allocations are smaller than previous emissions, so regulated firms have four basic options: 1) control emissions to exactly match their allocation, 2) "undercontrol" and buy allowances to meet this redemption requirement, 3) "overcontrol," and bank allowances for use in future years (when fewer allowances will be allocated), or, 4) overcontrol and then sell their excess. Cap-And-Trade systems have gained support over traditional command-and-control regulations from various corners because they greatly improve the likelihood of meeting pollution control goals while at the same time are more flexible and lower in cost than traditional approaches.

"Cap-And-Trade" systems have gained wide support as a regulatory strategy for managing and allocating emissions of pollutants to air and water. Several conditions must be met if these systems are to achieve the desired objective of achieving a given level of environmental quality at something close to minimum cost. It must be possible to:

1. Define and accurately measure the pollutant(s) of concern, their sources (both natural and anthropogenic) and their atmospheric fate and transport (i.e. understand the science);
2. Define the quantity of emissions that the regulated sources will be allowed to emit (the cap), and which will be available for trading in the market, an amount which can vary as a function of time (typically declining);
3. Find an acceptable method to allocate or auction permits to participating parties before trading is initiated;
4. Create and operate a market with enforceable contracts and rules in which specified classes of polluters must participate (or face penalties), and which involve enough participants to assure competitive behavior; and,
5. Demonstrate that all pollutants being traded cause similar damage (as in the case of a uniform well mixed pollutant), or if they do not, devise a weighting system acceptable to all participating parties that to normalizes damages across emission locations and times, and pollutant types.

Beyond these technical and economic requirements, there are sometimes also political requirements. For example, while it may not serve the objective of control at least cost, it may prove necessary to demonstrate some minimum level of "burden sharing", that is, to show that all emitters are doing something to reduce their own pollution, not just buying permits from others.

Several features of Cap-And-Trade programs are worth noting. First, they all have a highly coercive character – regulated sources are not generally given the choice of participating in the program. Indeed, Cap-And-Trade programs can be construed as simply the most flexible form of command-and-control regulation, and that many of the cost savings observed in the SO_2 example are due to this new flexibility (Burtraw 1996). In particular, no examples of "Coasian

[*] Other types of emissions trading are called Emissions Reduction Credits (Foster and Hahn 1995; Solomon and Gorman 1998) and "Open Market Trading" (Ayres 1994; Goffman and Dudek 1995). For a review of market-based instruments in general, see (Stavins 2000).

bargaining" have emerged. This term applies to theoretical systems of negotiation and litigation in which polluters are forced to pay those they harm for the damages inflicted (Coase 1960). Contemporary versions of this idea, sometimes travelling under the name "free market environmentalism" have been proposed (Anderson and Leal 1991)**pp 154-174**, but these suggestions ignore free-ridership and transaction costs. Moreover, in an attempt to place environmental protection wholly within the economic sphere and as far away from government and interest groups as possible, these proposals ignore both the idea that environmental (or at least health) protection is a matter of right, not negotiation, and the fact that property rights regimes themselves are created through political processes (Schlager and Ostrom 1992). One might also note the obvious problem with Coasian bargaining in the climate change context in that the vast majority of the aggrieved parties are not yet born.

Second, Cap-And-Trade programs are usually ascribed with the property of ensuring absolute emissions limits, given adequate monitoring and enforcement provisions. The lead phaseout program provided an example of the types of problems that could arise along these lines (Loeb 1990; Nichols 1997). As a result subsequent Cap-And-Trade programs in the U.S. have had very strict monitoring requirements and are generally acknowledged as being very successful in reducing emissions.

Third, in all of the Cap-And-Trade programs implemented so far in the U.S., the allowances themselves have been distributed free of charge to exiting sources (a practice called grandfathering), generally based on historical emissions. The advantage of this approach is that politicians can literally use allowances as bargaining chips to help arrange the necessary support to pass legislation enacting such systems (Joskow and Schmalensee 1998).

1.2 Greenhouse Gases, the Kyoto Protocol, and beyond

While there is currently no international trading system for managing the emissions of greenhouse gas (CO_2, CH_4, N_2O, PFCs, HFCs and SF_6), cap and trade systems are often advanced as one of the most promising regulatory tools available for addressing this problem. Table 1 assesses their applicability in view of the five criteria outlined earlier in this article.

Two types of difficulties are apparent, both instances of heterogeneity, a factor that can complicate the management of CPRs and in for emissions trading systems as well (Ben-David, Brookshire et al. 1999; Hackett 1992; Schlager and Blomquist 1998). The first arises from the absence of any overarching international authority that can create the needed market(s) and impose the needed regulatory judgments on all nations that are major source of emissions. For insights about how and whether these difficulties might be overcome, some of the US experience with NO_X trading is potentially relevant. The second set of difficulties arises from complexities and uncertainty in the science of greenhouse gasses (GHGs). If the only gas involved were CO_2 establishing an emissions trading system would be scientifically straight forward. If one wants to include other gasses, or if one wants to extend the system past emissions to include sinks, then scientific uncertainties become a major complication.

Past US experience with SO_2 and NO_X offers few relevant insights, except the encouragement that, if the uncertainties can be addressed, trading can be an efficient way to meet regulatory objectives.

1.2.1 Emissions trading under the Kyoto Protocol

Formal international efforts to control GHGs began in June of 1992 with the successful negotiation of the Framework Convention for Climate Change in Rio de Janeiro. The US is one

of 160 signatories to the agreement, which was ratified by the US Senate on October 7, 1992. While the FCCC commits the nations of the world to work to stabilize atmospheric concentrations of greenhouse gasses at a level that will "prevent dangerous anthropogenic interference with the climate system", no specific quantities, time tables or strategies are specified. The first Conference of the Parties to the Convention (COP-1) held in Berlin in 1995 lead to the "Berlin mandate" which instructed negotiators to seek short term legally binding targets and timetables. This in turn lead ultimately, in December 1997 to the Kyoto Protocol to the Rio Convention which calls for the developed, or "Annex 1," nations to collectively reduce their GHG emissions in the 2008-12 period by about 5% below 1990 emission levels. Different nations received different targets. The US target is 7%. Nordhaus et al. report that according to Administration sources this amounts to a reduction of 3% "when the accounting rules for the three industrial gasses and sinks are factored into the 1990 base line" (Reilly, Prinn et al. 1999). Since Kyoto additional Conference of the Parties meetings have tried to hammer out the details of how the agreement will be implemented. The next attempt to reach agreement will be at COP-6, to be held at the Hague in November, 2000.

There is no need in this paper to review the specific details of the Kyoto Protocol. At the insistence of the US, several provisions were included to allow flexibility in how the targets are met, including emissions trading. Also included are credit for sinks, for emissions reductions undertaken in non-Annex 1 countries, and multi-gas provisions (Reilly, Prinn et al. 1999). As we saw in Table 1, these inclusions raise fundamental difficulties for the design and implementation of trading systems.

There are several important issues that Kyoto does not address. First the proposed emissions reductions are only a small first step given that a reduction of the order of 60% will be needed to stabilize atmospheric concentrations at reasonable levels. Kyoto is silent on this much larger problem. While there are arrangements for assistance to developing countries, and schemes to allow developed countries to take credit for reductions they create in those countries, the only countries with numerical reduction obligations are those in Annex 1. The literature is filled with critical commentary on this fact. For example, Jacoby et al. argue that Kyoto "failed miserably at including poorer countries. Until the last minute, the negotiating text...contained a provision allowing non-participating nations to choose...on a voluntary basis, a level of emissions control it felt was appropriate to its circumstances...Several non-participating countries supported the idea, but the provisions was struck from the protocol because key developing countries - notably China and India - strongly opposed..." (Jacoby, Prinn et al. 1998). Congressional opponents to action to control GHG emissions have seized on this issue, insisting that the US can not be party to any agreement in which China and India have not agreed to reduction. These opponents frame their argument in terms of future emissions only, neglecting to note that CO_2 has a 100 year atmospheric life time. However, it is just as reasonable to frame the argument in terms of cumulative emissions, which shifts much of the blame onto industrialized countries, which have contributed well over 75% of all anthropogenic CO_2 that now exists in the atmosphere. Thus, as Morgan and Dowlatabadi have argued elsewhere, "while emission from the developing world will be an increasingly important contributor in the future, today, and for the next few decades, the developed world will continue to bear most of the responsibility for elevated levels of atmospheric carbon dioxide" (Morgan and Dowlatabadi 1997).

Another difficulty with the Kyoto accord is that no provision is made for applying a fraction of the enormous streams of wealth that would be created by emission taxes or cap and trade systems to investment in basic energy technology research, this despite the fact that it is widely

understood that technical innovation holds the key to solving the problem (Grubler, Nakicenovic et al. 1999; Hoffert, Caldeira et al. 1998; Morgan and Dowlatabadi 1997).

The Kyoto Protocol is an agreement among governments. If domestic or international trading were to play a significant part in meeting obligations under this agreement, it will ultimately result from agreements among nations

The US Energy Information Agency (Edmonds, Scott et al. 1999), estimated US costs (in 1992 dollars) of achieving carbon emissions 7% below 1990 levels in 2010 range from a low of 201 $/ton to a high of 317 $/ton without trading and from 91 $/ton to 160 $/ton with trading among Annex 1 countries.[*] Estimates of GDP loss without trading averaged 1.9% and with trading averaged 1.2%. Edmonds et al.(1999) have compared the projected benefits of greenhouse gas emissions trading in meeting the Kyoto Protocol in a number of multi-regional computable general equilibrium economic models that break out the energy sector separately and incorporate international trade in goods and services. Their comparison of results from five of these models yields estimated US costs (in 1992 dollars) of achieving Annex 1 carbon emissions 5.2% below 1990 levels in 2010 that range from a low of 59 $/ton to a high of 346 $/ton without trading and from 34 $/ton to 162 $/ton with trading among "Annex 1 countries". Savings from trading ranged from 13% to 67%, with an average value of 47% across the five models examined.

The emissions reduction targets in the Kyoto protocol are based upon historical performance. Because of the collapse of the Former Soviet Union there is a good chance that Russia and other former East-block countries would have excess emissions permits though 2010, which they could sell. A number of analysts have proposed that the most efficient way for the US to meet its obligations under Kyoto is to buy permits from Russia. Such proposals miss important political realities. First such a paper transaction would not result in much actual reduction in emissions. Second, the US Congress and the American public are unlikely to allow a transfer of billion of dollars per year to Russia in order to continue to be allowed to do what both countries were already doing anyway!

1.2.2 Early Action in the U.S.

While the United States is unlikely to ratify the Kyoto protocol, and is probably unlikely to undertake any other formal action in the next few years, there have been a number of efforts to get GHG management activities started. The Clinton Administration has mounted a voluntary program through the Department of Energy to attempt to meet the Kyoto targets (Clinton and Albert Gore 1993). However, this plan has had little effect, U.S. GHG emissions through 1996 have continued to increase, and projections for the near future show a similar trend (Energy Information Administration 1999; U.S. Environmental Protection Agency 1998a)

Several bills have been introduced in the US Congress to grant credit in any future regulatory system to firms that undertake control actions today (Nordhaus, Fotis et al. 1998). While in principle such "credit for early action" sounds like a good idea, which might get the country moving while Congress slowly builds the political confidence to act, a look at the details

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[*] We find the upper ends of these ranges (or any value much above $100/ton) extremely implausible for three reasons: 1) they do not reflect realistic politics – voters in many countries would simply not put up these costs; 2) technological innovation is not adequately represented in the models used to derive these costs (Azar and Dowlatabadi 1999); and, 3) even some currently available technologies (again not represented) could be deployed to keep costs at about $100/ton (Parson and Keith 1998). Nonetheless the relative benefits of emissions trading demonstrated in these models are illuminating.

leaves one far less confident. Most current proposals would create complex auditing and accounting systems, which in some cases would treat different industrial sectors differently. In the interests of giving credit to actions taken now they would impose substantial constraints on the freedom of action available in the future design of a national regulatory program. In addition, depending upon how regulatory arrangements develop subsequently, such credits could constitute a very large wealth transfer to those who earn early credits.

1.2.3 Early and voluntary efforts internationally

A few nations have already implemented internal market-based instruments for controlling CO2 emissions, most notably Sweden. Originally, this was a tax on most energy consumption, but this has recently been changed to an emissions trading program. More importantly, a recent announcement by the European Commissions indicated that emissions trading could be an integral part of Europe's strategy to reduce greenhouse gases.

In addition, a few industrial firms have begun to experiment with emissions trading. Most notably, BP-Amoco has started an effort to control CO2 emissions, and has decided to employ an internal (business unit-to-business unit) emission trading program to do so. Some financial services companies (generally those already involved in the U.S. pollutant emission allowance markets) have begun to facilitate emissions trades of various sorts, usually bilateral deals between a U.S.-based or transnational firm and an organization (often associated with a national government) in a less developed nation.

2 Inter-State NO_X Trading

The legal structure erected by Congress is key to understanding the successes and failures of inter-State NO_X Trading in the U.S. and in particular to understanding what inferences can be legitimately drawn for application in considering potential international emissions trading. Both the OTC NO_X Budget and NO_X SIP Call are designed to help the nation meet the standard for tropospheric ozone (or photochemical smog), which is part of Title 1 of the Clean Air Act.

Title 1 creates a governance structure called "conjoint federalism," under which the Federal Government (specifically the Environmental Protection Agency, or EPA) is responsible for setting air quality standards, creating and enforcing some emissions standards for new sources, while the State environmental agencies are responsible for controlling emissions from existing sources and operational controls such as automobile inspections.[*] To carry these activities out, States are required to develop State Implementation Plans (SIPs) which detail the steps they will take (in addition to Federal control measures) to attain the ambient standard. The EPA has oversight authority over the States and must approve their SIPs as adequately demonstrating (through a series of modeling steps) that the State will attain the air quality standard, and the EPA has strong enforcement capabilities if they do not.

A crucial feature of Title 1 is that the EPA does *not* typically regulate existing sources directly. Instead the States control existing sources through a system of air quality permits. When new evidence warrants, the EPA *can* announce a "SIP Call," which contain new requirements of States. In particular, it can define total emission reductions a State must make, but it cannot create specific requirements for any of the source categories that the States have authority over. In contrast, the EPA is given explicit authority in Title IV to create a national

[*] For some pollutants, such as toxics, the EPA regulates existing sources, but these come under Title 3.

SO_2 trading program, and the States have had little to do with the implementation of these requirements.

Further, Title 1 was originally written (in 1970) when tropospheric ozone was considered a wholly local phenomenon, and States were made responsible for attaining ambient standards only within their own borders (Farrell and Keating 1998). Subsequent research has shown that this is an inadequate understanding of the problem, and that significant "transport" of ozone and its precursors (especially NO_X) occurs between States. However, because this idea has so much economic and political impact, it has been (and continues to be) hotly debated (Keating and Farrell 1999). Changes to the Clean Air Act in the 1977 and 1990 added provisions for States to pursue legal means to force other States to control sources from which they believe pollution is entering their airshed. These provisions, called Section 126 Petitions, have never been successfully used, being consistently rejected by the courts, although further revisions to this section in 1990 have never been tested.

The States are thus put into a very odd position where they are required to individually meet an externally-imposed environmental standard for a pollutant that they (in many cases) have only partial control over. This has helped create a sharp division among the states, which can roughly be characterized as "upwind" versus "downwind" States, depending on whether they tend to contribute to NO_X pollution in other states, or tend receive it.[*] (This distinction will be discussed further below.) Adding to this division, is the variation in ozone levels among the States and the variation in the ways that the Clean Air Act treats them. Although transport is an important phenomenon in tropospheric ozone, it has a strong local characteristic as well. Urbanized areas, especially those along the mid-Atlantic coast from Washington to Boston, tend to have greater pollution levels, largely due to car and truck exhaust. These areas are subject to more stringent federal requirements than rural upwind areas. Thus, ozone transport creates the counterintuitive condition that NO_X sources (particularly sources with tall smokestacks) in relatively clean rural areas contribute to photochemical smog in relatively dirty urban areas. The political question is how should the burden of cleaning up the dirty areas be shared?

States do have some common interests in NO_X control. For one thing, they would all like to attain the ozone standard, both due to the Federal enforcement mechanisms and internal pressure from voters. In addition, they would all like to minimize the apparent costs to voters, and the real costs to firms within their borders. Emissions trading systems can accomplish this, and the larger the program the more efficient they tend to be. The costs of NO_X control were known to be very significant, an order of magnitude or more than SO_2 control on a per ton basis, adding to these motivations.

Comparing this arrangement to the politics of climate change, one can see that the case of NO_X control is more like potential CO_2 control efforts will be than the SO_2 case was, but it is still an incomplete comparison. The biggest similarity is that States are largely independent when it comes to establishing regulations for existing sources, and all the more so if they can support the claim that their emissions do not affect downwind States. The biggest difference is probably that they all have strong incentives to control NO_X emissions. In addition, they operate within an authoritative legal system and a single economic framework that permits virtually unfettered capital and trade flows among States. As we will see, the patterns of difference and similarity of

[*] In the eastern U.S., air tends to move to the west and to the north, and the States of the eastern seaboard are generally considered downwind of nearby midwestern and southern States.

interests go far in explaining the formation and lack of formation of inter-State emissions trading.

2.1 The NO_X Budget

The first example we will look at is a successful one, the NO_X Budget, that essentially applies to electrical generating units that are rated at 25 MW or larger and similar-sized industrial facilities (such as process boilers and refineries). About 90% of the NO_X emissions covered by the program come from electric power plants. It covers emissions from May through September in eight northeastern states of the U.S. There are over 470 individual sources in the program, owned by 112 distinct organizations (mostly private firms). The NO_X Budget follows previous command-and-control efforts to reduce NO_X emissions under Title I (NO_X RACT) and Title IV of the Clean Air Act. The program has three phases, the first was essentially a re-labeling of a the NO_X RACT program that the states were required to implement anyway. The second and third phases, use a cap-and-trade emission allowance program to reduce total emissions by 55%-65% (compared to uncontrolled sources) for 1999-2002 and by 75%-85% starting in 2003. For electric power plants, these restrictions are most often discussed by referring to the equivalent emissions rate limit corresponding to the final, most stringent emissions reduction requirement, measured in terms of heat input to the Boiler. For the NO_X Budget, this value is 0.15 lb. NO_X/mmBtu.

As indicated by the explanation above, the NO_X Budget could not be imposed by the Federal Government directly. Instead, it emerged from cooperative action by several northeastern States which had been grouped together into a special Ozone Transport Region by Section 184 of the Clean Air Act Amendments of 1990. At the same time, Section 176 created Transport Commissions for such regions, and the northeastern States were thus placed into the Ozone Transport Commission (OTC). The OTC was charged with "developing recommendations for additional control measures to be applied within all or part of such transport region if the commission determines such measures are necessary."

The EPA supported the development of an emissions trading program and used several approaches to stimulate cooperative action by the OTC states, such as funding several studies of multi-state emissions trading, and supporting several multi-state organizations dedicated to regional air quality management (U.S. Environmental Protection Agency 1992).[*] Further, the EPA offered to operate systems to track NO_X allowances and monitor NO_X emissions for any OTC NO_X program.

After the OTC had been created, it still took over 5 years for the states to develop the NO_X Budget, a process that occurred in two important steps. First, the States (with one exception, discussed below) signed a Memorandum of Understanding (MOU) on September 27, 1994 that committed them to emissions reductions as stated above. However, the States were not ready to agree to emissions trading yet, so the MOU presumed command and control regulation but did provide for the development of a "region-wide trading mechanism". The intent was for the states to negotiate the specifics of an emission trading regime and come to a mutually-agreeable solution.

[*] For the OTC itself, see http://www.sso.org/otc/. The other groups are the Northeast States for Coordinated Air Use Management (NESCAUM, see http://www.nescaum.org/) and the Mid-Atlantic Regional Air Management Association (MARAMA, see http://www.marama.org/).

While it is all well and good to support emissions trading in the abstract, the members of the OTC (State environmental commissioners and their staffs) found that there are many particular features of emissions trading that were complex and poorly understood. At the most basic level, some regulators are uncomfortable giving flexibility to firms, based on long experience of misleading rhetoric, extensive and drawn-out lawsuits and duplicitous behavior (e.g. falsified reporting in the lead phasedown program (Nichols 1997) and abuse of routine maintenance provisions to avoid new source requirements). Another issue was the ability of the States to retain as much control as possible in the program. In particular, the States demanded that they individually be allowed to allocate allowances to sources (rather than using a uniform formula. Each state was also concerned about a first-mover *dis*advantage; what if they went ahead and implemented a tough emissions reduction program only to find that some of the other states backed out of, or weakened, their commitment?

Probably the most difficult question, however, was the potential impact of cross-border trades in emissions allowances. Due to the directionality of the ozone problem, downwind regulators were concerned that firms in their States would overcontrol (and pass the cost on to in-state consumers), only to sell their excess allowances to upwind facilities (and presumably keep the profits). The upwind facilities thus don't need to control their emissions, and these would then be transported into the downwind state. To the downwind State regulators, this seemed like the worst of all possible outcomes since costs to their state would be higher while the upwind sources would not be "doing their share" to reduce emissions. To some degree this misses the point of emissions trading, firms with high control costs can "do their share" by buying emissions from firms with low control costs. The vision that state regulators have of in-state electricity consumers being stuck with the bill for emissions control is more an artifact of the monopoly franchise system for electric power than the economics of emissions trading. Moreover, the electric power system in the U.S now being restructured, and power generation is becoming increasingly competitive, downplaying the importance of this artifact.

While CO_2 and other greenhouse gases do not have this problem with the spatial pattern of emissions, the basic issue of where emissions reductions take place still matters. Nations are just as likely as States to want all parties in an emissions trading program to share in the burden of cutting emissions, and they are just as likely to prefer burden-sharing take the form of similar emissions reductions among all participants rather than similar costs of control.

The OTC States and the EPA took several steps to solve these problems. First, the EPA funded studies of emissions trading programs that showed no major geographic effects (ICF Resources 1995). Importantly, the States participated in the design of these studies, so they knew their questions had been addressed and they had reasonable confidence in the accuracy of the research. Second, the OTC States solved the image problem of emissions trading by emphasizing the regional emissions reduction, not the effects on in-state facilities specifically. Third, the states cooperated to develop a model emission trading rule that all could adopt, but which was flexible enough to match the peculiarities of each State's legal framework and gave each state control over how to allocate emissions (Carlson 1996). The actual amount of emissions available for allocation was fixed ahead of time in the agreement to control emissions in the first place (in the MOU) and not part of the negotiations on the emissions trading rules.

These efforts took several years to complete, and they did not quite produce a uniform emissions trading program. Figure 1 shows which OTC States have joined the NO_X Budget (medium gray) and which have not (dark gray). The pattern is interesting, the states at the extreme upwind and downwind have tended not to participate. Vermont and Maine (two of the

most downwind states) decided to operate traditional permit-based programs, because the small number of sources involved (less than three in each state) and their regulatory status did not justify the administrative burden of developing an emissions trading program. At the upwind end, Virginia did not join the NO_X Budget but it has not taken any other action to regulate the sources that would have been part of the program. In fact Virginia has been an uncooperative participant in the OTC negotiations all along, being the only state that did not sign the original MOU in 1994, and obstructing or ignoring many other OTC activities.

In general, this pattern of participation in the NO_X Budget matches the pattern of interests of the States. Those that participate fully both have cities on the eastern seaboard with severe ozone pollution problems, and are both upwind and downwind of other states in the OTC. The states that do not participate lack one of these two conditions.

2.2 The NO_X SIP Call

The NO_X SIP Call is still only a proposal, so it's final form is not yet known, but the development of the NO_X SIP Call so far is vastly different from that of the NO_X Budget, and the contrast is highly illuminating. As indicated above, the NO_X SIP Call originated with the EPA's announcement in the *Federal Register* on October 10, 1997 (finalized on October 27, 1998, *FR* 5736-57538), not from among the States themselves. In its announcement, the EPA identified 22 States, including all the OTC States (less Maine, New Hampshire, and Vermont) plus the states shown in light gray in Figure 1 which would need to reduce NO_X emissions due to their "significant contribution" to ozone pollution in downwind states. This finding met the legal requirements of Title 1.

The crucial feature of the NO_X SIP Call, however, is the emissions reduction requirements, which would in practice extend the 0.15 lb./mmBtu requirement embodied in the NO_X Budget to all 22 States. The EPA could not specify such a requirement, of course, so instead it developed a "budget" for each state and required that the states develop SIPs that would meet this budget. In calculating these budgets, the EPA estimated the total emissions from each state assuming existing control programs would remain in place, and that cost-effective emissions controls would be used on all sources. Among the additional controls that EPA identified as cost-effective were those that would bring coal-fired electric power plants down to 0.15 lb./mmBtu, plus a few others. Most importantly, the EPA applied *uniform* controls across all 22 States, ignoring any spatial effects.

To encourage the formation of an emissions trading program, the EPA included in it's announcement a provision that it would automatically approve SIPs that contained emissions trading provisions listed in the *Federal Register*. It also volunteered to take on many of the administrative and monitoring tasks, just as it did the NO_X Budget, and sponsored studies of emissions trading over the larger geographic area as well (Dorris, Agras et al. 1999; ICF-Kaiser 1996; U.S. Environmental Protection Agency 1998b).

The NO_X SIP Call was proposed after the NO_X Budget had begun to take shape, but before the emissions trading had started. It also closely (much too closely, according to some States) followed a large-scale effort to assess transport in the eastern United States, the Ozone Transport Assessment Group, or OTAG (Keating and Farrell 1999). This effort involved 37 States, including many of those partially visible in white on Figure 1. In contrast to the NO_X SIP Call, OTAG appeared to be created and led by a number of States, Illinois and the OTC States in particular. In reality, however, national politics and the EPA had a great deal to do with its

creation and operation (see Keating and Farrell 1999 pp. 29-34). Furthermore, in contrast to the OTC's MOU, the final report of OTAG did *not* contain any firm agreement on the need for deep NO_X emissions reductions (Ozone Transport Assessment Group 1997). Instead, OTAG's recommendations were very vague, they recommended a level of control from the status quo (i.e. nothing beyond what was already in the Clean Air Act) through the tight limits of the NO_X Budget. In addition, the recommendations support emissions trading generally, but OTAG was not able to develop and specific proposals. This allowed a wide range of States who essentially did not agree to nonetheless "come to consensus" on these conclusions. In this way the OTAG recommendations look very much like a typical agreement that international environmental negotiations produce: a relatively soft statement that re-affirms the status quo (Keohane, Haas et al. 1994; Victor, Raustiala et al. 1998).

It also appears that the NO_X SIP Call more or less conforms to the emissions reductions that the EPA had internally decided would be need even before OTAG started, based on a previous set of studies (Milford, Gao et al. 1994; Possiel and Cox 1993; Possiel, Milich et al. 1991; Roselle and Schere 1995). It is important to note that the analysis conducted subsequently under OTAG did not contradict these previous findings, rather it tended to increase the number of people (especially those outside the EPA) who were familiar with the results (Farrell and Keating 2000). It is also worth noting that the EPA at the time was pre-disposed to support emissions trading, which is most easily implemented with a uniform reduction requirement (Nichols 1999).

The NO_X SIP Call was spectacularly unpopular and generated as large number of lawsuits by the upwind states, who claimed that the EPA did not have the authority to issue the NO_X SIP Call and that the analysis underlying it was flawed in any case (Anonymous 1996; Flannery 1997; Flannery and Spatafore 1998). Most States subject to the SIP Call are planning to require controls on power plant NO_X emissions to help maintain air quality in their own states. Non-OTC states seem willing to impose emission trading requirements equivalent to 0.25-0.20 lb./mmBtu, which may be a 50%-65% reduction on average, but refuse to go further (Arrandale 2000).

Many of the downwind states filed Section 126 petitions at about the same time the NO_X SIP Call was announced, further adding to the dispute. Some time later, the EPA decided to grant several of these petitions (the disposition of some of them is as yet undecided), which were similar to the requirements of the NO_X SIP Call (Wald 1999).

After the NO_X SIP Call and Section 126 petitions were filed, numerous lawsuits were filed by the upwind States and power companies operating there.[*] Most recently, the courts have upheld the NO_X SIP Call, but further appeals are likely, and in any case the delay that accompanies (and some argue motivates) these legal actions has put off any program to control the regional aspects of ozone in the eastern U.S., whether emissions trading or otherwise, several more years into the future. Of course, if the upwind states eventually prevail, no such program may be developed.

3 Lessons

The political and economic conditions for the creation of a multi-lateral Cap-And-Trade system for NO_X among the States of the U.S. are more favorable than they are likely to be in

[*] Simultaneously, many of the same interests were engaged in a separate legal battle over the ozone standard itself.

most international settings. In this sense, the NO_X Budget and NO_X SIP Call are "best case" examples, and explaining the vast differences in outcomes is important.

3.1 Some observations *counter* to previous work

A few observations of these cases run counter to those that have been made of prior examples, and it is important to point these differences out.

3.1.1 Existing regulations

Several authors have claimed that the absence of prior regulations was an important feature of the success of the SO_2 program. This is not true for the NO_X Budget, nor is it true for the SO_2 program either! Power plant SO_2 had been controlled for human health reasons beginning in the 1970s, at the Federal level for new sources and the State level for existing (Ackerman and Hassler 1981). Moreover, the emissions trading provisions of the 1990 Clean Air Act Amendments clearly state that emissions trading cannot result in any violations of the Title 1 health based standards for SO_2. Of course, it is true that Federal SO_2 controls on existing power plants, and that controls designed to address acidification were new. In any case, the NO_X Budget is clearly an addition to pre-existing regulations on both the State and Federal levels, and is designed to achieve long-standing human health goals.[*] Thus it appears that Cap-And-Trade programs can be used to supplement or replace existing command-and-control regulations just as easily as they can be used to regulate a new pollutant. What is difficult is to combine the two sorts of regulations (Foster and Hahn 1995).

3.1.2 Symbolic power

Emissions trading programs are sometimes thought to have less symbolic power; politicians supposedly cannot earn the same level of admiration and support for enacting an emissions trading program as they can for "getting tough with polluters" through command-and-control approaches. While there is some truth to this hypothesis, it appears that in the U.S. at least a reasonable portion of the public understands that emission trading programs do in fact have teeth. This can be seen in the positive media stories about the NO_X Budget and the vociferous language used by States attempting to avoid the NO_X SIP Call.

It may be difficult to generalize this observation to the international community, however, since the U.S. is quite singular in its use of emissions trading. Other nations (and especially public opinion in other nations) may continue to misperceive emissions trading as an ineffective means of emissions control, particularly since most countries are less willing than the U.S. to rely on the market for things like health care or labor supply. In addition, buying emissions allowances looks to many like avoiding any responsibility for the problem (despite paying for cleanup elsewhere), and this may pose fundamental political impediments.

3.1.3 Flexibility and simplicity

Two of the standard prescriptions for emissions trading is for simplicity of design and flexibility for the participants, however the inter-State NO_X cases show that it is all too easy to be *too* simple and *too* flexible. The uniform standard embodied in the NO_X SIP Call is a case of an overly simple design. Had the EPA responded to the upwind (mostly Midwestern) States concerns about the effects of distance, some form of emissions trading might already be in place. In fairness, if it is in fact true that 85% reductions across all 22 States are necessary to achieve

[*] The same can be said for California's RECLAIM program (Lents and Leyden 1996).

the ozone standard in the cities of the eastern seaboard, than the EPA's approach has considerable merit. (To some degree, of course, a debate about what is "*scientifically necessary*" is misleading and misses the point. Many combinations of local and regional emissions control plans would attain the standard, the real question is which one is most easily accomplished *politically*.)

Further, the flexibility that firms have in timing their emissions within the five-month season may prove to be excessive (Farrell 2000; Farrell, Carter et al. 1999). Although there is less of a temporal and spatial pattern in the global warming system than in the tropospheric ozone system, the basic lesson still holds: there must be a close match between the regulations to control an environmental problem and the physical and social phenomena that create it in the first place.

3.1.4 Leadership vs. Strong-arming

A common view of the way an international emissions trading program could be developed is for the U.S. to "lead" by establishing a domestic emission trading program that other countries could copy (Solomon 1995). However, the evidence provided by the NO_X Budget and the NO_X SIP Call strongly counterindicate, the program that was centrally-sponsored (the SIP Call) failed, while the program that was cooperatively developed (the Budget) has turned into a significant success. Further, during the OTAG discussions on emissions trading, the disparities between the OTC States and EPA on one side, and the remainder of the States was very large (Farrell and Keating 1999 pp. 70-80). The OTC States were comfortable with the idea of emissions trading and understood the policy implications of various options, while the upwind states were much less familiar with the concepts and were concerned about being tricked into an agreement that was disadvantageous due to being less well informed. In part this may have been a delaying tactic on the part of upwind States, and in addition the same problem of uniform controls emerged. The OTC States assumed (or asserted) that uniform controls were necessary for the creation of a successful emissions trading program, while the upwind States insisted on finding a way to enable emissions trading between regions with differentiated control requirements.

The lesson is clear, expertise in emissions trading does not translate into a leadership position, rather it is far easier for advocacy of this approach to look like strong-arming. This is especially true of how the upwind States viewed the NO_X SIP Call. In the NO_X Budget case, the key to a successful program seems to have been cooperation and efforts to build trust, not advocacy disguised as "leadership." With the U.S. reputation as an international bully (deserved or not) in addition to its position as the leading advocate of emissions trading, this problem seems particularly relevant to attempts to develop an international CO_2 trading regime.

3.1.5 Reading market signals

If creating Cap-And-Trade programs is a relatively new and uncertain endeavor, reading and interpreting the signals these programs produce for signs of success or failure is virtually untried and unknown. These programs are vastly different from traditional environmental regulations, and the markets they create are quite different from other sorts of financial markets. The newness of these markets, plus the changes in the electric power sector have produced a number of questionable interpretations. One is that emissions trading markets are "thin" (i.e. lightly traded) and thus inefficient or subject to high transaction costs. However, the fact that these markets are quite concentrated (a small number of firms own many allowances and many power plants) means that many firms can achieve considerable savings simply by re-allocating allowances internally, something that would not be picked up in market transaction data (Burtraw 1996). Some observers seem to think that a large volume of traded emissions is a

necessary condition for success, partly because many early models of emission trading programs forecast this outcome. Second, periods of low allowance prices during an early part of the SO_2 market have been widely misinterpreted, and the advantageous conditions that produced those bargains may not occur in other markets (Schmalensee, Joskow et al. 1998; Smith, Platt et al. 1998). Third, some have suggested that transaction costs in these markets are high, yet none of the participants have made such complaints.

Several consistent and convincing signals have been observed, though, 1) consistent low allowance prices (volatile periods aside) 2) an increasing reliance on the market and an increasing sophistication in how it is used, and 3) significant emissions reductions (Ellerman 1998; Ellerman and Montero 1998; Farrell 2000; Klier, Mattoon et al. 1997; Mueller 1995). This combination suggests that despite the oddities of these markets and short-term glitches, the major Cap-And-Trade programs operate more or less as advertised to reduce total emissions at relatively low costs. Even more encouraging are the signs that these programs have stimulated technological change, which will help bring down costs even more in the future (Conrad and Kohn 1996; Farrell 2000).

3.2 New observations

Several new observations about the implementation of emissions trading systems can also be made, based on the cases discussed above.

3.2.1 Prior necessary condition: Agreement to control

The most important observation is that a political agreement to control emissions has preceded agreements to use of Cap-And-Trade systems. This was most obvious for the case of the NO_X Budget: the original MOU committed the States only to NO_X controls, the emission trading program emerged later on. It took considerable effort after the MOU was signed in 1994 before the States were able to agree to drop command-and-control approaches for the NO_X Budget.

In the case of the NO_X SIP Call, the lack of any firm agreement between upwind and downwind States on the level of emissions reductions needed has made it unlikely that an emissions trading program will emerge. Even if the courts eventually force the upwind States to comply with the budgets set by the EPA in the SIP Call, they may reject the implementation suggested by the EPA, and some of them have indicated that they will. Similarly, the lack of resolution during the OTAG process hampered discussions on recommendations for an emission trading program (Keating and Farrell 1999 pp. 76-84).

This observation supports the description of a two-stage decision process among heterogeneous actors devising a CPR given by (Schlager and Blomquist 1998).

3.2.2 Participation related to similarity of interests

Another part of Schlager and Blomquist's argument is that the position of the actor relative to the resources can affect their willingness to participate in solving CPR problems (pg. 102). Both of the cases examined here strongly support this contention, and suggest that it can be broadened somewhat: participation in the development of an emissions trading system varies according to the interests of potential participants, greater similarity implies greater likelihood of participation.

In the case of the NO_X Budget, the fact that Virginia has not joined is a good example of an actor that perceives itself as immune to the adverse effects of others (to use Shlager and

Blomquist's phrase). But Maine and Vermont have chosen not to join for a different reason – their level of industrialization is so low that it seems like too much of an administrative burden. And even though Maryland did join the NO_X Budget, they were forced by an industry lawsuit to delay for a year. The basis of the suit was that Maryland did not have a NO_X RACT program before the NO_X Budget was to go into effect, putting regulated sources in a particularly difficult situation. Thus, because the State was a little behind the rest of the OTC States in terms of regulation, it's ability to participate in the NO_X Budget was affected. On the other hand, the states facing the largest emissions control costs , such as New Jersey, were the strongest supporters of emissions trading.

Even stronger examples exist in the NO_X SIP Call case. Here, not only did State environmental agencies vary in their support for emissions trading according to their location, but so did firms. The usual monolithic "no" to more regulation shattered during the OTAG negotiations, as firms located in down-wind states came to recognize they would be advantaged by a larger emissions trading program and they became stronger supporters (Keating and Farrell 1999 pp. 93-4).

3.2.3 Trust (but verify)

Participants in the NO_X Budget negotiations and OTAG assessment all highlight the importance of developing "trust" between the participants. In general, this came from working closely together on problems that were to some degree shared. A closer examination, however, shows that in practice "trust" meant different things in each case, but more importantly, States came to trust that the *process* they were participating in could not be manipulated against their interests. In this sense, they only trusted other States as far as they could verify their actions.

While they were developing the NO_X Budget, the OTC members came to trust that emissions trading would work to solve their problems, and to trust each other to accurately represent their own situations during group meetings. This trust developed over the course of several years as a result of repeated face-to-face interactions in multiple OTC-related venues (e.g. technical sub-committee working groups as well as the OTC itself), and through the realization that duplicitous behavior could be detected relatively easily through this process. Third parties (such as the EPA) aided in this process. Thus, while they eventually trusted each other to actually implement back at home whatever they agreed to together, OTC members took steps to verify this was the case.

Similar mechanisms were at work in the OTAG process, with similar outcomes, despite the greater the distrust between the states beforehand and the shorter time available to overcome that distrust (Keating and Farrell 1999 pp. 138-9, 144-6). The fact that no permanent follow-up was created after OTAG ended and thus no verification mechanisms were available helps explain why the NO_X SIP Call has created so much opposition.

3.2.4 States want to retain as much control as possible

It is hardly surprising that States wanted to retain as much freedom to implement the multi-lateral emissions trading program as possible. In particular, in the NO_X Budget case, States insisted on retaining control over how the allowances were allocated. As it turns out, the States have adopted very different processes for allocation (for instance, some held public meetings, others did not) but these variations have had no observable effect on the performance of the system.

4 Conclusions and recommendations

Despite our pessimistic view on the prospects of an emissions trading system (or any other meaningful effort by all Annex 1 nations) based on the Kyoto protocol, we feel that it is certainly feasible for emissions trading to become part of the international response to climate change. The lessons from the study of Common Property Resources (CPRs), and from the cases above of efforts to develop inter-State emissions trading within the U.S. federal system clearly show reason for optimism. Here we provide some closing remarks.

4.1 Work for an agreement to control emissions before agreeing how to implement

Combining negotiations on how much to control CO_2 emissions with negotiations on how to implement such an agreement is unwise. This is especially true in the early stages, when control costs are poorly known, negotiators are highly uncertain about the rules for any emissions trading regime, and the very act of obtaining any agreement to control is an achievement. The more issues on the table at any one time, the more opportunities for opponents of control to delay and confuse the issue. Indeed, the most sure way to engage CO_2 emitters usefully in the creation of a reliable, efficient emissions trading program is to establish a worse alternative (i.e. command-and-control regulations or a tax) as the status quo. The real trick is mustering the political will to make the decision to control emissions, everything else is secondary (and easier).

One important reason to separate negotiations about controlling emissions from negotiations about the choice of implementation mechanism is that it is likely nations will vary on their ability to agree on these two aspects. The NO_X trading experiences clearly show that independent jurisdictions will fight hard to maintain as much of that independence as possible. The set of nations willing to agree to CO_2 controls, with implementation to be decided later is surely larger than the set willing to agree to CO2 controls plus a specific implementation mechanism. Moreover, since emissions trading is a relatively new concept for some nations and more familiar to others, it may well be that, at first, some nations will want to use more traditional approaches, and locking them out of an agreement on the principal issue of CO2 control on this less important basis would surely be a loss.

4.2 Look for emissions trading first among similar nations

Once an agreement to reduce CO_2 emissions is in place, we expect emission trading systems would arise among similar nations, where the most relevant dimension to measure similarity on is national capability to implement emissions trading.[*] This could easily happen outside of the Kyoto framework, possibly as a simple bilateral program at first, although nations that develop such a system would certainly be justified in claiming that they were *jointly* meeting their Kyoto targets thereby. Other relevant dimensions of similarity may be the presence of fossil resources, the structure and size of energy taxes, the ability of their economies to produce innovation and allow labor adaptations, the role of environmental issues in national politics. Nations that share (at least partly) energy system infrastructures (i.e. electrical generation capacity and petroleum product supply chains) and strong economic ties (e.g. the European Union or Mercosur) may be the most likely to start an international emissions trading system.

[*] We can assume these nations also have a similar (high) national interest in CO2 control, else they would not have joined the agreement to begin with.

However, we would *not* necessarily expect nations that develop an emissions trading program have any particular similarity in CO2 control costs. Indeed, emissions trading saves the most money when control costs vary most, so nations that see an opportunity to meet emissions control goals more by inducing reductions in another country than at home might well join, as well as countries that see an opportunity to improve their balance of trade and possibly stimulate energy system investments by overcontrolling their emissions and selling the excess. Nonetheless, there are surely limits to the amount of money nations would be willing to see leave the country in order to provide a global public good such as climate stabilization, perhaps one or two multiples of current foreign aid budgets. For these reasons (and for others stated above), we would expect that either the prices or volumes of internationally traded CO_2 emissions allowances would be relatively small. This observation suggests that balance of trade concerns might be an additional factor (besides those traditionally mentioned by economists) that could reduce the efficiency of international emissions trading systems.

4.3 Growing Control from the Bottom Up

Our most important conclusion, however, is that there is absolutely no need to assume comprehensive top-down international emissions trading programs that involve significant binding commitments are the only way to develop and effective, efficient GHG reduction strategy. Indeed, such approaches will almost certainly fail, since key countries such as the US, China and India will not agree to participate. The diplomats will put a good face on things and keep trying, but for at least the next decade it is unlikely that all the world's major states will simultaneously be prepared to sign up for a serious program of carbon dioxide emissions control.

Skolnikoff has argued that the US, and especially the Congress, will be slow to become an active participant in any

> "...issue in which the UN and the international community must play a central role. There is a climate of xenophobia in the Congress, reflected to some degree in the electorate that is challenging the role of the nation in world affairs and particularly in the work of the UN and its associated bodies....The mindless fears of UN 'black helicopters' are certainty an extreme, but the current mood, often reflected in Congressional statements and votes, sees a vocal portion of the public turning away from foreign involvements...and rejecting policies that are perceived as in any way infringing American sovereignty. In this context, an agreement negotiated under the auspices of the UN that if carried out would certainly have an impact on the American economy is immediately suspect." (Skolnikoff 1999)

US domestic political concerns are not the only problem. As Jacoby et al. have noted, developing international institutions that will facilitate policies to minimize the cost of reducing GHG emissions,

> "...requires solving the monitoring and enforcement problems necessary to implement efficient international trading of rights to emit [GHGs. It also]...requires an institutional structure that can exploit the cheapest abatement opportunities, wherever they may be found...This is a tall order. The international trade regime developed under the General Agreement on Tariffs and Trade, now the World Trade Organization, hints at the difficulties involved. This regime grew and evolved over time, adding countries and goods along the way, peacefully resolving conflicts between national interests...By the standards of international affairs, the WTO has been a stunning success, but it took 50 years of hard work..." (Jacoby, Prinn et al. 1998)

Jacoby, his co-authors and many others, have argued that, because GHGs are global pollutants, they can not be managed without an overarching international accord. Fortunately, as both the WTO example just cited, and many examples in the literature on the management of common pool resources, suggest (Ostrom, Burger et al. 1999), a top-down international

framework may not be the only route to a global regime for managing carbon dioxide. The NO_X Budget case shows it is possible for independent jurisdictions to agree on how to implement an emissions trading system, but the limits in this example and the outright failure (so far) of the NO_X SIP Call warn us that it is not easy.

Indeed, a top-down approach may not even be the best route. Several countries, such as Norway and the Netherlands, have begun to take unilateral action. While these actions are dismissed by some as limited and self serving, they reflect their citizen's genuine political commitment. The history of international environmental protection shows quite clearly that effective regimes start slowly. The diplomatic community needs to figure out how to encourage the growth of local and regional regimes, and encourage their coordination so that ultimately they can coalesce into a set of global arrangements which encompass all major states.

An evolutionary bottom-up strategy has several benefits. Concerned states and regions can start today. As different early adopters try different strategies, the world will get an opportunity to evaluate alternative approaches and learn from mistakes. Early adopters can provide the inspiration, and proof of concept, to inspire, or shame, citizens in other countries to take action. Some will argue that a bottom-up approach can never work, because nobody will go first for fear of free riders. However, national environmental policies are often not primarily driven by economic considerations. There are growing numbers of people who believe that the world must act, and are willing to assume some extra burden, and provide an example for others.

If a bottom-up strategy is going to work, the diplomatic community needs to take concrete steps to support and encourage sub-global carbon management efforts. For example, early adopters may want to impose a domestic carbon emissions tax on power plants, process industries, and on the production or use of transportation and heating fuels. These states might be willing to have their industries face a modest competitive disadvantage in world markets. However, they will certainly not want to disadvantage domestic industries. Thus they will want to impose nondiscriminatory boarder adjustment tariffs on the carbon dioxide releases that are implicit in imports. This might be done through a set of default values that importers can replace, at their option, with real values verified by some impartial international auditing entity. Such a system would have to be made compatible with World Trade Organization rules, which today might disallow such taxes on the grounds that they are discriminatory, or inappropriately consider process. But, trade rules are always in flux and multilateral agreements are treated more favorably than unilateral initiatives. With some effort, several nations might be able allowed boarder adjustment externality taxes on global pollutants, even if not on local pollutants.

The diplomatic community could also help by opening a forum for discussions among states who want to act now. As more states begin to develop control strategies, there will be growing needs to coordinate, to reconcile tax-based approaches with cap-and-trade approaches, to figure out how to treat multinational firms, how to promote the basic technology research needed to create the intellectual capital that the market will need to develop future clean energy systems, and ultimately, to coalesce the voluntary network of controls into a more binding international system that includes all major industrialized and industrializing states.

Research into CPRs has shown societies of all sorts have managed to develop sustainable means for managing vital resources, but that many have failed to do so and perished. We need to act now to encourage initiatives by individual states and regions so that we can learn how best to move the world's economies toward a lower-impact, more sustainable future. Fortunately, it may be possible to develop such strategies from the ground up.

Table 1: Criteria for systems of tradable emissions permits, and two applications

	Criterion	Applicability to OTC NO_X Budget	Applicability to GHGs
1	Define and accurately measure the pollutant(s)...their sources ...and their atmospheric fate and transport.	Sources are easily identifiable and most already have NO_X Continuous Emissions Monitors (CEMs) as part of the SO_2 Acid Rain Program monitoring requirements. Fate and transport is reasonably well understood, although varies from source to source, and with weather conditions somewhat	Sources are relatively straight forward for CO_2. They are significantly more difficult for other gasses such as CH_4. Sinks are still a source of considerable uncertainty for all GHGs, including CO_2. Other local and regional pollutants can have large impacts.
2	Define the quantity of emissions that will be available for trading (the cap) ... as a function of time.	Specified by OTC NO_X MOU. Derived through the use of photochemical models and engineering-economic estimates. Imposed on sources by State governments. Declines over a 5 year period	Within a nation this could be done though national law. Internationally it would require bilateral or multilateral international agreements.
3	Find an acceptable method to allocate permits to participating parties;	Varied by State, some determined allocation through legislation, others left the decisions up to regulators.	Same as 2 above, but complicated by the existence of multi-national firms which operate in a number of national jurisdictions.
4	Create and operate a market with enforceable contracts and rules in which specified classes of polluters must participate (or face penalties) ...	Copied from pre-existing SO_2 example and readily implemented through State laws and regulations.	Contracts and rules could be established within any nation. Existing international law would support some cross-national contracts. Bilateral or multilateral agreements would facilitate this. This criterion would be easily met for GHGs in most nations and internationally.
5	Demonstrate that all pollutants being traded cause similar damage...or... devise a weighting system acceptable to all participating parties	Area of greatest disagreement. However, spatial variation was shown to be unimportant given the configuration of sources and deep emissions reductions. Temporal differences were largely ignored, although their effects are uncertain.	Essentially true on a spatial basis. However, the GHGs vary very significantly in warming functions and atmospheric lifetimes, implying important intergenerational judgments for multi-gas trading. Within a nation these could be set by national law. Between nations bilateral or multilateral international agreements would be required.

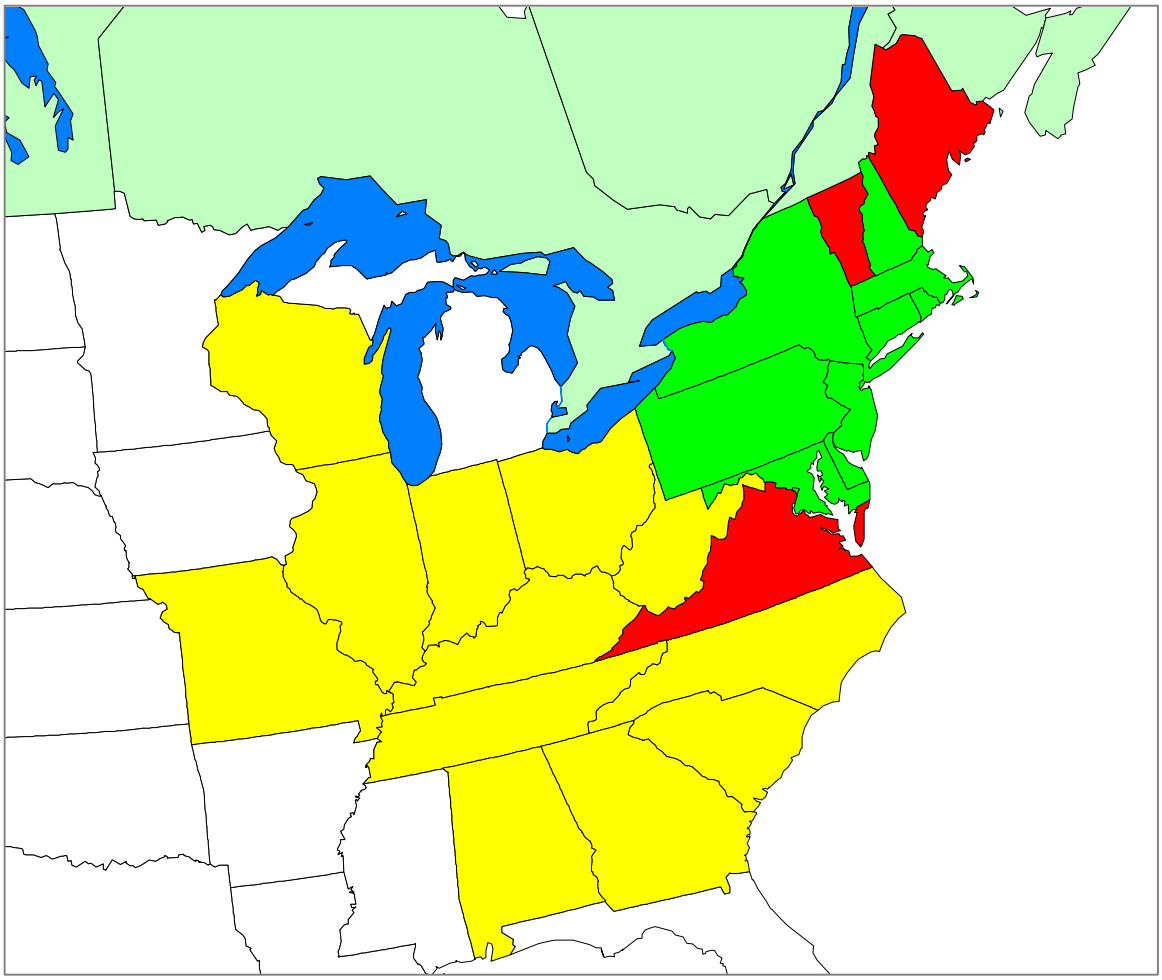

Figure 1: NOx Budget and NOx SIP Call States

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