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## Using Economic Incentives in Environmental Management: The Case of Marketable Permits for Pollution Control

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# USING ECONOMIC INCENTIVES IN ENVIRONMENTAL MANAGEMENT:

# THE CASE OF MARKETABLE PERMITS FOR POLLUTION CONTROL

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# 1 INTRODUCTION

The use of individual transferable quotas for bycatch (IBQ) or target species (ITQ) has been proposed as a potential solution to the bycatch, discard and underutilization problem in the Gulf of Alaska (GOA) and Bering Sea/Aleutian Islands (BS/AI) groundfish fisheries. The objective of this report is to provide information that can be used to design and evaluate such programs by summarizing the nature and effectiveness of environmental protection programs that include the use of marketable rights.

A central tenet of organizational theory is that allocation and definition of property rights have important implications for market performance (Hahn and Hester 1989a). When ownership is not attached to a particular user, but rather to groups of unrelated users, the problem of the "commons" arises. That is to say, users of a common resource do not fully internalize the costs of resource depletion. A common result is that the resource is "overused" relative to what might have occurred with individual private ownership (Hardin 1968).

Many areas of environmental policy have been analyzed using the framework suggested by the problem of the "commons" including: pollution control, regional planning, wetland protection, and fisheries management. The most prolific area of research has been in the design of market-based solutions to pollution control. Economists frequently argue that environmental protection programs could be designed and operated more efficiently if the government were willing to define a system of marketable property rights. With marketable pollution rights, a given pollution objective can often be met at a lower cost making higher standards more acceptable to industry. In addition to economic efficiency, incentive-based approaches are thought to stimulate greater innovation and technical change.

# 2 THEORETICAL BASIS FOR MARKETABLE PERMIT PROGRAMS

In the past few years, marketable permit programs have moved from relatively obscurity to the fore as tools for environmental management. Most marketable permit programs to date have been developed for regulating air pollution. However, a small number of programs have also been used to control water pollution, urban sprawl and wetland loss. Marketable permit programs are typically implemented by regulatory agencies which issue permits to firms allowing some set level of impacts such as emissions or effluents. Individual firms are then allowed to trade (i.e., buy and sell) these permits. When control costs differ between firms, companies facing higher control costs will benefit by purchasing permits from firms able to reduce emissions for less than the offered price. As a result, reductions are made where they are least expensive while the overall emissions target is still achieved. In market-based systems, regulators do not attempt to determine the optimal pollution control technologies as these decisions are left up to the individual firms. Firms have incentives to develop and implement improved control technologies because they can realize savings either by selling any unused emissions permits or by having to purchase fewer emission permits (Teitz 1994).

While theoretically appealing, the success of marketable permits greatly depends on how they are implemented in a given setting. Marketable permits only succeed where firms face different control costs and where a market in permits develops. Transaction costs such as regulatory requirements and information costs impose market barriers and reduce cost savings. In addition, assuring the environmental effectiveness of permit trading requires accurate permit tracking, monitoring and enforcement. For a marketable permit program to be worthwhile as a matter of policy, the costs of developing, implementing and administering the system must be outweighed by actual savings in control costs. At the same time, the level and certainty of environmental protection must be maintained.

The United States has had over twenty years of experience with a variety of marketable permit systems. In 1974 the Environmental Protection Agency (EPA) began its first forays into market-based approaches to pollution control by designing limited emissions trading programs (Hahn and Hester 1989b). Since then, regulatory agencies have experimented with marketable permits in a wide range of settings including: air pollution, water pollution, solid waste, land use, and wetlands mitigation. The literature on the use of economic incentives for environmental protection is immense. Before examining the actual experience of specific trading programs, it is worthwhile to review the theoretical basis for marketable permits.

## 2.1 Effects on Economic Efficiency

Much of the literature on marketable permits is theoretical in nature. On a theoretical level, marketable permit programs are inherently more efficient than traditional command-and-control approaches. In other words, they are expected to achieve environmental goals at a lower cost. Some theoretical research on marketable permits simply attempts to provide a theoretical basis for permit systems without addressing a specific problem context. This research broadly defines the types of markets and permit systems that could increase the economic efficiency of environmental programs (Hahn and Hester 1989a). The overall conclusion emerging from this research is that marketable permits represent the most cost effective approach to achieving environmental objectives (Atkinson and Tietenburg 1982; Dales 1968; Hahn 1989a; Hahn 1989b; Hahn and Hester 1989a; Hahn and Stavins 1992; Montgomery 1972; Steidlmeier 1993; Tietenburg 1974; Wiley 1992).

A second body of applied theory evaluates the cost savings that could accrue under marketable permit systems in specific settings. Economists have performed numerous mathematical simulations comparing cost and environmental quality in a particular environmental context usually air or water pollution. EPA (1992) and Tietenburg (1985) reviewed the bulk of quantitative studies completed in the United States. Typically, the cost of a system of uniform standards is compared with an optimal system that could, in theory, be reached by using a system of marketable permits (Hahn and Hester 1989a). The conclusion of this body of research is that marketable permit systems could produce significant savings in pollution control costs, by up to 90 percent in some cases (Tietenburg 1985). No studies of marketable permits are known to exist that reach the opposite conclusion (EPA 1992).

In recent years, as actual trading programs have developed, empirical studies have attempted to explain the actual performance of environmental markets. Many of these studies have identified specific aspects of environmental problems that tend to facilitate or restrict permit trading. In a review of retrospective analyses of emission and effluent trading systems Atkinson and Tietenburg (1991) concluded that in all the marketable permit programs examined, actual cost savings fall well short of projections. In every case trades have been fewer and cost savings smaller than was predicted by economic modeling.

Economists cite numerous and varied reasons why many marketable permit programs have failed to live up to expectations. Coggins and Smith (1993) explored the welfare effects of emissions trading in the electrical utility industry where firms face multiple regulatory restraints. They concluded that marketable sulfur dioxide ($SO_2$) permits in the utility industry cannot be relied upon to guarantee either productive efficiency or economic efficiency because of interference in the market by state public utility commissions. Cason (1993) examined the seller incentives of EPA's emission allowance trading auction and concluded that the EPA's sealed bid/offer rules generate significantly biased price signals and reduce the efficiency of the allowance market. In the area of water pollution Letson (1992a) examined point source/nonpoint source water pollution trading programs and concluded that uncertainty about the effectiveness of nonpoint source control approaches has stifled trading.

The literature on pollution control also examines the distributive effects of different types of regulatory systems to society at large. The literature on air pollution policy suggests that uniform command-and-control strategies tend to be regressive. For example, Gianessi et al. (1979) demonstrated that uniform technology-based standards simply generated higher prices and transmitted the regulatory burden disproportionately to the poor.

### 2.2 Stimulus to Innovation and Technical Change

Most marketable permit programs are based on the quantity and composition of emissions rather than a uniform technical standard. Consequently, marketable permit programs are more likely to provide incentives for innovation and technical change than command-and-control approaches. When emissions are the only basis for determining compliance, a firm can minimize its compliance cost by reducing its emissions to the point where its marginal cost and marginal benefit of further reductions are equal and by developing and using lower cost methods of meeting the emissions standards. In command-and-control approaches, where technology-based standards are commonly used, firms may have little incentive to innovate. This is either because the technology itself, rather than the level of emissions, is often the standard or because other methods of meeting the emissions standard are not permitted. Some studies have even found that technology-based standards produce a negative incentive for firms to innovate (Dwyer 1992). With technology-based standards, regulators are often obligated to require the use of "best available technologies". Firms that develop new control technologies on their own often find their innovations have become the new "best available technology" and the basis for even tighter control standards.

Studies that have examined various incentives for technological change and innovation have found that pollution taxes provide the greatest stimulus to innovation with marketable permits providing an intermediate level of stimulus (EPA 1992). However, long-term changes in behavior, technology and investment are among the most difficult economic effects to document. For that reason, relatively little is known of the long-term effects on innovation that occur as a result of different pollution control systems (EPA 1992). The best available evidence suggests that existing environmental policies provide only mild stimulus for technological change and innovation (Cramer et al. 1990).

### 2.3 Effects on Environmental Protection

The literature comparing marketable permits with command-and-control approaches focuses almost exclusively on economic efficiency or the cost side of the comparison. However, to judge the worth of marketable permit programs as environmental policy, it is also necessary to compare the environmental effectiveness of such programs with traditional command-and-control approaches. Generally, marketable permit programs are designed to produce environmental effects that are comparable to a command-and-control alternative. However the environmental effectiveness of such programs may be better or worse depending on the details of market design.

Some trading programs require trading ratios in excess of one. In other words, more than one unit of emissions reduction is required for every extra unit allowed. Sometimes high trading ratios are required to account for uncertainty about the effectiveness of control methods. In other cases, the intent of high trading ratios is to produce additional decreases in total pollution compared to what would be achieved with command-and-control approaches.

On the other hand, it may be more common for marketable permits to provide somewhat less reduction in overall pollution than command-and-control based programs. Oats et al. (1989) found that uniform command-and-control approaches often result in "over-control" beyond a pollution standard, whereas trading-based approaches only just achieve the standard. This is because in most regulatory settings, some firms are able to reduce pollution to levels below what is required by regulation. With trading, those excess reductions are canceled by excess pollution from other sources.

## 3 ATTRIBUTES OF MARKETABLE PERMIT SYSTEMS

The design options for marketable permit systems range from small shifts in command-and-control approaches to free-wheeling pollution markets. However, all trading systems can be characterized in terms of a number of important attributes: (1) incentives may accrue either before or after the time of pollution; (2) permits may be assigned to either individuals or groups; and (3) standards may be based on either the mass or the rate of discharge.

## 3.1 Credits versus Allowances

Marketable permit programs can involve either credits or allowances. The difference between credits and allowances is the time at which the right accrues. Credits must first be earned by demonstrating reductions in pollution. Allowances are pollution rights which are issued before hand. A credit is created after pollution has occurred, when a firm emits less than its allowable limit. To earn credits, a polluter is required to show that its reduction in emissions is a surplus and meets other regulatory tests. Regulators grant credits when reductions are below the regulatory baseline. In a credit program, the regulatory agency usually certifies the creation of the credit at the end of a pre-designated accounting period. In a credit-based system regulators have two opportunities to regulate the creators of credits. The first is when the baseline and ground rules are established and the second is when the firm applies for credits (EPA 1992).

In an allowance system, trading involves future pollution. Firms are granted quasi-rights or allowances to emit pollution on an annual or some other calendar basis. Firms are "allowed" so many tons per year to pollute; if a firm does not need all of these "rights," it may sell them. Once the regulatory agency sets allowable limits for each firm, the firm can add to its limit or reduce it by trading in allowances. Regulatory agencies might track trades, but do not necessarily certify every trade before hand. Until the past few years, most marketable permit programs were credit systems, although allowance systems are becoming more common.

Allowance systems are generally considered a freer form of markets than credit systems. That is because the property right attached to pollution reductions under allowance systems is more secure. In some credit programs, where a regulatory agency must certify pollution reductions before credits are granted, some regulatory agencies have refused to issue credits because of changing regulations or other discretionary reasons. In other cases, where firms are guaranteed that a given level of reductions will earn a given level of credits, there may be little functional difference between allowances and credits (aside from differences in accounting procedures).

## 3.2 Group Permits versus Individual Permits

The group permit approach is most commonly used to control nonpoint sources of water pollution (Teitz 1994). The regulatory body establishes the maximum level of allowable discharge for a water body, but instead of issuing individual allowances, dischargers as a group, are held responsible for controlling pollution sources. In group permit systems, groups are free to distribute allowances among members in any manner they chose. With a group permit system, the group itself, rather than the regulatory body generally establishes the guidelines for trading.

### 3.3 Mass-Based Limits versus Rate-Based Limits

Programs to regulate pollution may be based on the total mass discharged, the rate of discharge, or both. Command-and-control regulations commonly limit the rate of emissions, but not the total amount (for example, federal automobile tailpipe standards). Some programs regulate both rate and mass at the same time. Ambient air quality programs frequently use rate-based restrictions to assure that emissions loading on any particular day (or under specific atmospheric conditions) do not exceed air quality standards. At the same time, air quality programs usually impose mass-based restrictions on an annual basis to meet regional air quality targets.

Trading systems have been designed to achieve both mass-based and rate-based limits. The distinction between the two is important because mass limits are a significantly different regulatory burden than rate limits. In fact, analysts have found that many of the most difficult problems associated with trading programs come from the limit itself rather than from allowing firms to adjust their limit through trading. Issues such as monitoring, baselines, and enforcement are all limit-related rather than trading-related. In many marketable permit programs, the allowance unit and total number of allowances are based on mass calculations, while the initial distribution of allowances among firms is based on a combination of rate and mass considerations.

## 4 MARKETABLE PERMITS IN PRACTICE

Theoretical analyses and empirical studies have produced a rough consensus about the conditions that may be necessary or beneficial for marketable permit programs to succeed. Nevertheless, it is difficult to evaluate whether or not permit trading is the optimal regulatory approach to a particular environmental problem at the theoretical level because the factors that influence success or failure vary tremendously in practice. To provide a realistic view of how marketable permit programs work in practice, this section examines a range of currently functioning trading systems.

### 4.1 Credit Systems

Until recently, most marketable permit programs have used credits rather than allowances. The EPA's emissions programs, the lead trading program, point source/nonpoint source water pollution trading, and transferable development rights programs are all examples of credit systems.

#### 4.1.1 Emissions Trading Under the Clean Air Act: An Overview

To date, the bulk of our experience with marketable permits had been with air pollution. The first limited efforts at creating marketable permits in the United States were emissions trading systems developed as part of EPA's ambient air quality programs. These programs emerged in the 1970s as policy recommendations by EPA to state and local clean air agencies to alleviate the costs of meeting some of the more expensive elements of the 1970 Clean Air Act. When Congress drafted the Clean Air Act, it gave no serious consideration to the magnitude and distribution of control costs. In addition, Congress prevented EPA from even considering costs when setting ambient air quality standards (Bleicher 1975). Congress felt that public health and the environment could not be compromised by concern for corporate profits and apparently had faith that ambitious air quality standards and short deadlines would force industry to develop the necessary control technologies (Bonine 1975). Congress' faith in technology produced a political and legal dilemma for the EPA. One element of the Act prohibited both construction of major new facilities and major modifications to existing ones in so-called "nonattainment" areas (Dwyer 1993). The Clean Air Act, if strictly enforced, effectively banned the construction of new manufacturing facilities in most urban areas due to the fact that major cities in 45 states failed to meet initial ambient air quality standards. EPA, as well as state and local regulatory agencies, were forced to confront head on, the conflicting political goals of environmental protection and economic development. To provide a way of allowing continued economic development in "nonattainment" areas, EPA developed four specific types of credit programs referred to as *netting, offsets, bubbles* and *banking*.

Netting was introduced in 1974 as EPA's first foray into market-based pollution programs. Netting allows an expanding facility to avoid strict standards for new operations to be applied on plant modifications by using internal trading (within the same plant) to keep total emissions below a pre-determined level. Under netting, new source of emissions would be allowed if emissions from other sources within the same plant are reduced proportionately. Because "insignificant" increases are allowed under netting, some environmental degradation may result (Hahn and Hester 1989a).

Offsets have been used since 1976 to allow continued economic development in "nonattainment" areas where the Clean Air Act prohibits all emissions increases. Under this policy, firms are able to build new facilities, or modify existing ones, so long as they employ strict pollution controls on the new source and offset all residual emissions by reducing emissions at other existing sources (Hahn and Hester 1989a). With offsets, exchanges may occur between different firms or different facilities within the same firm, while netting only applies to different discharge points within a single facility.

Bubbles were introduced in 1979. Under this policy, an existing facility is regulated on the basis of an imaginary bubble placed over the complex. Emissions levels from individual sources within the complex can be freely traded as long as total emissions do not increase. Most trades involve emissions within one plant but there have been a few multi-plant bubbles (Hahn and Hester 1989a). While netting and offsets only apply to new sources of pollution, bubbles apply to all sources of pollution within a plant or geographic area.

Banking, which was first allowed in 1979, provides a mechanism for firms to save emissions credits for future use. EPA established guidelines for banking programs but state or regional agencies must set up and administer the rules governing banking. Banking does not generally involve trading *per se*. Rather, it is usually applied to emissions from a single source over time (Hahn and Hester 1989a).

During the reauthorization of the Clean Air Act in 1977, Congress debated the more extensive use of economic incentives. Many legislators viewed them as politically risky and as an unwarranted delegation of the public interest to private actors. In the end, a modest offset program was formally authorized within the Act itself (Hahn 1989a)[1]. However, when the Clean Air Act was again amended in 1990, Congress authorized and in some cases mandated a much broader range of marketable permit programs to deal with specific problems such as urban smog and acid rain (Dwyer 1993).

### 4.1.2 Emissions Trading in Practice: The Los Angeles Basin Experience

While the Clean Air Act requires EPA to set ambient air quality standards, actual implementation is delegated to state and local agencies. In the late 1970s, local regulators in the South Coast Air Quality Management District (SCAQMD), which covers the Los Angeles basin, began to experiment with offset trades under guidance from EPA (Dwyer 1993). With SCAQMD taking the lead, many other California districts began to adopt rules governing offset trades. To date, however, the results of the offset program in the Los Angeles basin have been disappointing. In SCAQMD, which reportedly has the "most developed and well functioning" trading program in the nation, only a handful of firms complete offset trades with each other each year (Hahn and Hester 1989b). In addition, two thirds of the credits sold (by volume) have been in conjunction with firms closing their facilities. The extent to which these plant closings are attributable to pollution incentives rather than other factors has not been examined. While there have been a significant number of intra-firm offsets, producing considerable savings, no market in inter-firm permits has emerged (Dwyer 1993).

Analysts have attributed the lack of inter-firm offset trading to a number of factors. First, the offset program itself is designed to suppress demand. Most existing firms cannot buy offsets. Only those firms undergoing major modifications or construction of new facilities may purchase offsets. Expanding firms must first install the latest pollution control technologies regardless of the availability of less expensive offsets. SCAQMD regulations also create exemptions ("thresholds") for entire categories of small facilities and for modifications that result in relatively small emissions increases. As a result, few firms need to acquire offsets, demand is suppressed and the market is undeveloped (Dwyer 1993).

A second reason for the lack of offset markets is the tendency of existing firms to hoard their credits, thereby restricting supply. Most plant managers believe that they will need additional credits in the future to respond to new SCAQMD emission reductions or to accommodate future expansion plans. Firms also fear, with some justification, that if they reduce emissions, the District will simply lower their emissions limits and place restrictions on future increases. In addition, firms have found that the use of new technologies at one plant has, in some cases, been the basis for mandatory controls at other plants (Dwyer 1993). Additional market barriers include the transaction costs associated with locating a seller, undertaking appropriate engineering studies to quantify the emissions reductions, negotiating a price, and securing

[1] Prior to 1977, netting and offsets had emerged as EPA policy but were not mentioned in the Clean Air Act itself.

SCAQMD approval (Hahn and Hester 1989b).

For these reasons, the majority of trades have involved firms that have ceased operations and have no economic motive for withholding their credits from the market (Dwyer 1993). SCAQMD's regulations make it extremely difficult to create tradable credits by any other means than closing a plant. Given how strict the District's rules are, getting more emission reductions by over-controlling emissions is difficult. In addition, the fee SCAQMD charges for processing credits is so high (SCAQMD issues separate permits for individual pieces of equipment) that it is not cost effective for most companies with multiple permits to generate credits (NAPA 1994). However, by allowing firms that will cease operations to sell their credits, the probability that such permits will be allocated efficiently among existing and new operations is increased.

Despite the limited success of the offset program in the Los Angeles basin in generating a market, SCAQMD regulators, industry and environmentalists have shown a growing interest in the use of economic incentives. The 1990 Amendments to the Clean Air Act, which openly encouraged incentive based systems, were instrumental in encouraging the development of a new marketable permit system for the Los Angeles basin. In 1992, state and federal regulators, as well as representatives from industry, environmental groups and labor developed an ambitious program to replace the existing command-and-control structure with marketable permits for sulfur oxides, nitrogen oxides, and hydrocarbons (Dwyer 1993). This new emissions trading program, known as the Regional Clean Air Incentives Market (RECLAIM) began on January 1, 1994. This program establishes annual limits on the amount of air pollution a plant can emit. These limits are ratcheted down on an annual basis. Firms that are able to realize reductions in excess of their annual limits are granted credits which they can sell to firms that have difficulty meeting baseline requirements. While several thousand firms will eventually be regulated under RECLAIM, the current program affects only 387 plants in the Los Angeles basin (Bornstein 1994). Although the RECLAIM program has been heralded with great fanfare as a successful example of marketable permits, it is still too early to judge the effectiveness of the program. The first emissions credit auction was postponed until late 1994 to give firms more time to convert their emission reduction credits and develop compliance plans (Heinsohn and Karey 1994).

### 4.1.3 Lead Trading Program

The lead trading program, formally known as "inter-refinery averaging" was instituted by EPA as part of a regulatory program that mandated reductions in the amount of lead added to gasoline (Hahn and Hester 1989a). Although EPA began regulatory efforts to reduce lead in gasoline as early as 1974, trading in lead credits did not begin until 1982 when EPA imposed new, lower limits on lead content. The trading program was developed in response to concerns that some refineries, especially small ones, would have trouble meeting the new standards and would benefit from a program providing extra flexibility for a period of time. In 1985 EPA further reduced the amount of lead allowed in gasoline and specified that lead trading would end in 1986. Prior to 1985, unused lead credits expired at the end of every quarter. Beginning in 1985, refineries could "bank" credits for their own future use or sale to others. While the trading program ended in 1986, firms were allowed to use banked rights until the end of 1987 (Hahn and Hester 1989a).

Under the program that expired in 1986, rights to add specific quantities of lead to gasoline could be freely traded between refineries. EPA set national standards specifying the quantity of lead that could be added to gasoline. The quantity of rights to which a refiner was entitled was determined by the quantity of gasoline produced by that refiner and the current lead standard. Refineries that added less lead than was allowed could sell all excess lead credits in a one-to-one ratio. Refineries exceeding the lead standard were required to obtain lead credits in an amount equal to the excess. Transactions were reported to EPA at the end of each calendar quarter, and each refiner was required to have a net balance of lead credits greater than or equal to zero for the quarter (Hahn and Hester 1989a).

Trading of lead credits could be internal or external. In other words, refineries could use lead credits themselves by adding more lead to their gasoline at some point during the quarter than would otherwise have been allowed, or they could sell credits to another firm. The trading program was successful without compromising any of the environmental objectives of EPA's lead reduction program. Lead trading shifted the use of lead between refineries but it did not increase the total amount of lead that could be used. In is unlikely that trading resulted in greater overall use of lead by refineries. Because lead is the most cost-effective method of raising octane levels in gasoline, virtually the entire amount of lead permitted would have been used by refineries with or without a trading program.

Economists consider the lead trading program to be the most successful example of a marketable permit program to date (Hahn and Hester 1989a). The lead market itself was extremely active. During the programs existence, upwards of 60 percent of all refineries participated in either trading or banking. By the programs end, the percentage of lead credits banked or traded exceeded 50 percent of the total lead used (Hahn and Hester 1989a). Although EPA has not collected data on the actual cost savings realized by refineries as a result of lead trading, the agency estimated that lead banking alone could produce savings of as much as $225 million to refineries. Anecdotal evidence placed the combined savings of both trading and banking in the hundreds of millions of dollars (Hahn and Hester 1989a). Without trading in lead credits, two alternatives were likely: (1) the phase-down would have take longer or (2) there would have been a short-term contraction in the supply of gasoline and possible supply disruptions in some areas (EPA 1992).

### 4.1.4 Point/nonpoint Water Pollution Trading: Colorado and North Carolina Examples

Since 1972 the emphasis of national water quality programs has been the control and elimination of pollutants from point source discharges.[2] Although problems with some point

[2]Point source discharges are defined as coming out of a pipe from a single source such as factories or sewage treatment plants. Most point source discharges are regulated under the Clean Water Act through the National Pollutant Discharge Elimination System (NPDES) permit program. Nonpoint source pollution may be thought of as runoff from agricultural and urban areas where the identification of a single source is impossible. Fertilizer

source pollutants such as oxygen-demanding waste and bacteria have lessened, water quality has not improved commensurably because nonpoint source contributions are increasing as a share of the nation's water quality problem (EPA 1990). Centralized "command and control" programs have had difficulty regulating nonpoint sources which are decentralized and dependent on localized features such as land use patterns and agricultural practices (Leschine and Shigenaka 1988). For this reason, there is growing interest in marketable permits as a method of regulating nonpoint sources of water pollution.

Point/nonpoint source trading is one mechanism used for dealing with nonpoint source problems. Point/nonpoint source (PS/NPS) trading borrows the "bubble" or "offset" concepts from air pollution regulation and applies them to watershed management. A "bubble" (or "bowl" for a watershed) adds the discharge levels for all sources in the watershed and allows for adjustment of the levels of individual discharges as long as the total does not exceed the target aggregate level. PS/NPS trading has come to mean giving municipal treatment plants and industrial dischargers the option of reducing nonpoint source contributions rather than requiring further point source reductions (Letson 1992a). The advantage of PS/NPS trading is that it allows dischargers to pursue the most cost effective methods of water quality improvement. PS/NPS trading has the added advantage of drawing nonpoint sources into the regulatory scheme without the need to regulate them directly.

Programs at the Dillon and Cherry Creek Reservoirs in Colorado and a similar program for the Tar-Pamlico River basin in North Carolina are among the few examples of PS/NPS trading to date (Letson 1992a). Lake Dillon (Denver's source of drinking water) is an interesting example. By the early 1980's Lake Dillon's water quality was declining rapidly due to excessive nutrient loading. As is often the case, point source dischargers were required to carry much of the responsibility for cleanup. Surrounding towns had to consider adding expensive state-of-the-art wastewater treatment facilities or face moratoriums on new development. Studies showed, however, that the bulk of phosphorus coming into the lake originated from nonpoint sources. Much of the NPS phosphorus was attributable to runoff from golf courses, parking lots, construction sites and seepage from septic tanks. Consequently, the "Dillon Bubble" strategy was designed to allow growth in the basin while at the same time maintaining -- or even improving -- the water quality of Lake Dillon (Zander 1991).

An integral part of the Lake Dillon strategy was a plan for PS/NPS trading. Under the plan, wastewater treatment facilities were awarded 1 pound of PS phosphorus credit for the removal of 2 pounds of NPS phosphorus. In other words, treatment plants could finance NPS reductions in the community in leu of making PS reductions at the plant. Because many NPS controls are inexpensive low-tech approaches such as grass filter strips and detention ponds, municipalities found PS/NPS trading to be economically viable even at a 2:1 ratio. In the past few years, however, the operating efficiency of existing tertiary treatment facilities in the

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runoff from farms, golf courses and lawns; animal waste from farms and feedlots; oil runoff from highways; and silt from logging operations and construction sites are all examples of nonpoint source pollution. Until recently, most nonpoint sources of pollution have fallen outside the regulatory framework.

basin has greatly improved, reducing the need for phosphorus trading. While PS/NPS trades continue to be proposed, the program has changed somewhat to include NPS/NPS trading. As the area continues to grow, new development will likely produce new sources of phosphorus. To counter this increase, the plan allows developers to mitigate for newly created sources of phosphorus by reducing or eliminating "old" nonpoint sources (Zander 1991). This use of NPS/NPS trading is analogous to compensatory wetlands mitigation.

The Tar-Pamlico River PS/NPS trading program began in 1989, however it is still appears to be in the formative stages. Although trading is allowed in the program, no economically motivated trades have occurred to date for two primary reasons. First, the lack of a nutrient model means that regulators do not yet have accurate information about the basin's water quality dynamics. For this reason they are reluctant to promote trading. Second, most of the basins' point source dischargers have been able to meet mandated reductions with relatively inexpensive internal modifications which has reduced the demand for PS/NPS trading (Apogee Research 1992).

Despite the Tar-Pamlico experience, we may be reaching the point in many instances where NPS reductions are cheaper than further PS controls. Letson (1992) identifies two conditions that must exist for PS/NPS trading to be economically viable. First, inexpensive NPS reductions must exist that are similar in nature to the PS reductions they are to replace. Second, the uncertainties stemming from prediction, monitoring and control of nonpoint sources must not overwhelm potential savings. Several watershed studies produced for the EPA suggest that these conditions do exist in some watersheds.

A study of the Wicomico basin in Maryland showed significant potential savings. It was estimated that for one treatment plant, trading could provide savings of $64,000 in meeting a 25 percent reduction target and $245,000 in meeting a 75 percent reduction target (Industrial Economics 1987). Other case studies in the Great Lakes basin and Honey Creek watershed in Ohio indicate similar possible savings exist (Letson 1992a). Unfortunately there are no larger cost comparison studies that can provide insight into the demand for PS/NPS trading on the national level.

## 4.2 Allowance Systems

Marketable permit systems have not commonly used allowances, in part, because of a reluctance on the part of regulators to certify rights in advance of the polluting activity. To date, there have only been two examples of marketable permit programs using allowances in the United States: the acid rain program and the chlorofluorocarbon production trading program.

### 4.2.1 The Acid Rain Allowance Program

The most significant marketable permit program to emerge as a result of the 1990 Clean Air Act Amendments is the sulfur dioxide ($SO_2$) allowance trading market which was mandated by

Congress and designed to reduce acid rain in the Northeast. The $SO_2$ trading program was designed from the outset as a compromise to break the decade-long deadlock in Congress between Northeastern and Midwestern representatives over who should bear the cost of cleaning up the nation's acid rain problem (Fulton 1992). Under this program, total emissions of $SO_2$ from all electric utility power plants in the continental United States are capped and ratcheted downwards on an annual basis to meet the Clean Air Act's overall goal of halving $SO_2$ emissions nationwide by the year 2000. EPA issues annual emissions limits to each utility in the form of allowances. Utilities are then allowed to meet their emissions limits using any method they like the most common being a shift to low-sulfur coal mined mostly in the West, installing scrubbers, or purchasing additional allowances from other utilities. The acid rain program established a national market in $SO_2$ emission allowances allowing utilities from any part of the country to freely trade allowances without regard for the effects that the trade will have on the geographic distribution of air pollution or acid rain deposition. Phase I of the program affected 110 of the dirtiest coal-fired electric utilities which are all located in the eastern half of the country. Phase II, scheduled to begin in the later half of the decade will include all sizable sources of sulfur dioxide (Hausker 1992).

The $SO_2$ allowance trading program was designed to achieve two specific goals that Congress was unable to deal with in any other way. First the program was intended to spread the cost of acid rain reduction among utilities and ratepayers in a way that all regions of the country would find acceptable. Congress struggled for a decade with the distribution problem considering and rejecting such measures as federal subsidies and national utility taxes. By establishing marketable permits, Congress expected that utilities would decide among themselves how to distribute the cost (Fulton 1992). The second goal of the program was to lower the overall compliance costs of the acid rain provisions of the Clean Air Act. Initial projections estimated potential savings to the electric industry of at least \$1.5 billion annually (Burtraw 1991) or 20 percent of the estimated \$5 billion in annual compliance costs (Goldburg and Lave 1992). Much of this potential savings results from the wide disparity in compliance costs between power plants. Compliance is significantly cheaper for some plants due to the technology in use when they were constructed and the type of coal they were designed to burn.

In 1992 EPA selected the Chicago Board of Trade to conduct the public auction of $SO_2$ emissions allowances. The first public auction was held on March 29, 1993 and attended by approximately 100 electric utilities. This initial auction generated \$21 million in trades and included a "spot auction" for 1995 allowances and an "advance auction" for the year 2000 (Bukro 1993). Utilities were also free to arrange private trades in allowances. Since 1992, a number of private trades have occurred including several between utilities and smelters. Most analysts, however, consider the level of trading, to date, to be disappointing and lower than originally projected (Torrens and Platt 1994).

The most significant reasons for the lack of $SO_2$ trading are related to the monopoly characteristics of the coal-fired electric utility industry rather than to the design of the market itself. The electric utility industry is, perhaps, as far removed from the competitive ideal as any industry in the United States. Most utilities hold at least some monopoly power in their output markets and are tightly regulated by state public utility commissions (PUCs) (Coggins and Smith 1993). The market barriers to trading in $SO_2$ allowances fall into three categories. First, utilities whose rate of return is tightly regulated may have little financial incentive to reduce pollution control costs that are traditionally passed on to consumers. In Pennsylvania, for example, state law requires the profits of allowance trading to be passed on to utility ratepayers which removes any incentive for utilities to play the market at all (Fulton 1992).

Second, PUCs have shown a willingness to overrule the decisions of utilities and reject allowance trades on the basis of regional environmental or economic issues. In New York, for example, the PUC has expressed an unwillingness to approve any trades between New York and Midwestern utilities that could increase $SO_2$ emissions in the Midwest -- the primary source of acid rain deposition in the Adirondacks. In Florida, PUC commissioners have indicated they will block out-of-state allowance trading all together to prevent any reductions in statewide power generating capacity and the loss of jobs that might occur if utilities chose to purchase cleaner generated electricity from utilities in other states (Fulton 1992).

Finally, Midwestern state legislatures have passed laws intended to protect the regions high-sulfur coal industry by requiring utilities to use the more costly scrubber option instead of switching to low-sulfur western coal. In Ohio, American Electric Power (AEP) estimated the capital costs of installing scrubbers would be $800 million while switching to low sulfur coal from the West would cost only $200 million. Other utilities throughout the region predicted similar savings which led economists to predict that the allowance trading system would encourage most utilities to switch fuel rather than installing more costly scrubbers. Indeed, much of the predicted savings from allowance trading is based on utilities choosing the less costly low-sulfur coal option over scrubbers. Nevertheless, AEP's proposal to switch to low-sulfur coal generated vehement opposition in the state legislature from the Ohio coal industry. Within months the legislature had passed a tax credit for Ohio coal burned in local powerplants, and the state PUC indicated that future rate increases might be jeopardized if AEP did not reconsider the scrubber option. Finally, AEP abandoned the low-sulfur option and asked the state to float $800 million in tax-exempt bonds to finance the scrubber option.

In Illinois the state legislature has taken the more drastic steps to protect the local coal industry. The Illinois legislature recently passed a law requiring the state's two largest utilities, Commonwealth Edison of Chicago and Illinois Power Co. of Decatur, to burn high-sulfur Illinois coal at the state's four largest powerplants. In essence, the state mandated that the utilities install scrubbers at the four powerplants and gave them advance permission to pass the cost likely to exceed $1 billion on to consumers around the state (Fulton 1992). Similar examples of state protectionism are emerging in Indiana, Kentucky, Pennsylvania, and West Virginia.

In some instances, state interference in utility decision-making might be expected to increase trading if trades are perceived to be more economical than the costly scrubber option. However trading has not appeared to increase as a result of state interference. This may be due to the "ratcheting" nature of the program in that allowances are decreased over time. Because all utilities will face increasingly stringent control requirements in the future, any current supply of surplus allowances is likely to evaporate in the future. For this reason, utilities can only consider allowance trading a short-term cost saving option rather than a permanent solution to their pollution reduction requirements. All utilities believe it necessary to move forward with new control technologies (whether low-sulfur coal or scrubbers) over the longer term (NAPA 1994).

These and other deliberate attempts by states to prevent utilities from taking advantage of market-based incentives represent a serious threat to the success of the acid rain allowance trading program. Economists now worry that, if enough states drive up the cost of compliance or interfere with the market, the expected cost savings will disappear (Fulton 1992). If environmental compliance costs are seen as excessive, consumers may be unwilling to finance additional environmental measures in the future. On the other hand, some of the sponsors of the program are less concerned with the lack of trading. They point out that the primary purpose of the acid rain allowance program was breaking the political deadlock between Northeastern and Midwestern states rather than cost savings. During the 1980s, states such as Illinois refused to accept the notion that they should bear the entire cost of installing scrubbers in order to protect their coal mining industries. They argued that Northeastern states, where acid rain is a large political issue, should share the costs of emissions reductions. Today however, faced with mandatory reductions in $SO_2$ emissions, Midwestern state legislatures have suddenly found the political will to transfer the costs of protectionism to local consumers (Fulton 1992).

### 4.2.2 Chlorofluorocarbon Production Allowance Trading

A second allowance program to emerge from the 1990 Clean Air Act Amendments was the chlorofluorocarbon production allowance trading program. In 1988 the United States ratified the Montreal Protocol on Substances that Deplete the Ozone Layer. The Montreal Protocol called for a cap on the production of chlorofluorocarbons at 1986 levels, with further reductions in 1993 and 1998. EPA issued initial regulations implementing the Montreal Protocol in 1988. Title VI of the 1990 Clean Air Act Amendments called for additional restrictions on chlorofluorocarbon production (EPA 1992).

In late 1991 EPA issued temporarily a final rule that (1) apportioned baseline chlorofluorocarbon production allowances, (2) provided for gradual reductions in allowances, and (3) permitted the transfer of allowances among firms (56 FR 49548-580). The only limit placed on trading was that during trades, the seller's remaining allowances are reduced by the amount transferred plus one percent of the amount transferred (EPA 1992). The chlorofluorocarbon allowance program is similar to the lead trading program in that both were designed to ease the short-term transition costs of a rigid reduction program.

Chlorofluorocarbon trading was welcomed by industry, and EPA considered it to be a relatively successful example of a trading program. Nevertheless, no detailed estimates of the cost savings produced by chlorofluorocarbon trading are currently available. EPA believed that one reason an incentive-based program was so readily accepted by both industry and the regulatory community was that the chlorofluorocarbon problem was being attacked for the first time. Unlike other areas of pollution control, incentive-based efforts were not undermined by an existing command-and-control regulatory framework (EPA 1992).

### 4.3 Rate-Based Averaging Programs

A final category of trading programs are those based solely on rate. Emissions averaging to control motor vehicle pollution is, perhaps, the best known example of rate-based trading. Title II of the Clean Air Act called for an emissions standard for nitrogen oxides that represented the maximum degree of reduction available with a goal of attaining a reduction of 75 percent in the "average of actually measured emissions" from heavy duty truck engines (EPA 1992). The emissions standard for particulates was set in a similar fashion. While vehicles and engines had to be certified on an individual engine basis, section 206(g) allowed manufacturers to comply through the payment of a non-conformance penalty sufficient to remove whatever competitive advantage they obtained from making high emitting engines. EPA's implementation of these requirements allowed manufacturers to comply by averaging together the emissions performance of all heavy duty truck engines they produce (EPA 1992). A similar proposal for averaging automobile emissions included in the Bush Administration's 1989 Clean Air Act reauthorization, failed to win Congressional approval.

Emissions averaging is also permitted under EPA's Emissions Trading Policy to meet industry-specific Reasonably Available Control Technology (RACT) standards (EPA 1992). For years EPA has allowed RACT requirements to be met through emission averaging. In 1980 EPA allowed can coating manufacturers to compute daily weighted average volatile organic compound (VOC) emissions in conjunction with a plant-wide emission limitation for satisfying RACT requirements (EPA 1992). This so-called "cross-line" averaging is also to other industrial sectors. However, little data is available on the extent to which "cross-line" occurs or the savings afforded to industry (EPA 1992).

## 5 CRITERIA NECESSARY FOR THE SUCCESS OF TRADING PROGRAMS

The experiences of existing programs and the theoretical literature on market design provide some general criteria necessary for successful permit trading programs. Success not only depends upon whether a trading program functions well once in place, but also upon whether the problem context allows a market to be developed, approved, and implemented. The following are a series of conditions which analysts have identified as either necessary or helpful for the establishment of a successful trading program.

### 5.1 Physical Context

For trading programs to be successful, the environmental problem must be physically amenable to a trading approach. In the case of pollution control, the harm must relate to the total mass loading of pollution to the environment and be independent of particular sources. Trading may not be appropriate where concentrations of pollutants in certain areas (hot spots) pose a concern since a reallocation of pollutant sources could exacerbate the problem. In addition, trading may not be appropriate where sensitivity to pollutants varies significantly within a proposed trading zone. In both of these cases, the reallocation of impacts through trading could defeat environmental protection goals.

In some instances, concerns about equity and market viability have taken precedence over concerns about the physical appropriateness of a trading zone. The acid rain program is an excellent example. Evidence suggested that $SO_2$ emissions from Midwestern utilities are most responsible for acid rain in the Northeast. Nevertheless, the trading program established a national market in allowances with no consideration of the environmental effects of trades between regions. Some analysts argued that $SO_2$ emissions from utilities in the Southeast (and parts of the Northeast) had little effect on the acid rain problem because prevailing winds carried most emissions out over the Atlantic where deposition is harmless.[3] They were concerned that allowance trading could cause large-scale shifts in emissions from the Southeast and Northeast to the Midwest exacerbating the acid rain in the Northeast (Hausker 1992). However, legislators felt that a national market was necessary to achieve an equitable distribution of control costs across all regions of the country. Legislators also rejected a multiple standards approach based on location (e.g., contribution to acid rain) on equity and competitiveness grounds.

Differences in the type of impact are a second reason the physical context of a problem is not always appropriate to trading. In the case of water pollution, PS and NPSs do not generally discharge the same pollutants limiting the number of problems to which trading could be applied. Water treatment point sources generally discharge bacteria and oxygen-demanding waste while nonpoint sources tend to contribute sedimentation and nutrient loading. Both sources are responsible to different degrees for different types of water quality problems.

Calculation of the net social benefit of the reduction of a given unit of pollutant is dependent on a wide range of factors including watershed dynamics, ambient pollutant levels, and risk assessment techniques. However any attempt to quantify and compare the social costs of different pollutants would be highly suspect. For this reason, all PS/NPS trading programs have dealt with exchanges in the reduction of a single nutrient -- usually phosphorus. Extension of PS/NPS trading programs beyond nutrient control is difficult because many pollutants, such as biochemical oxygen demand (BOD), are nonconservative (degradable). Current regulation of nonconservative pollutants such as BOD requires the staggering of discharges over time and location so that ambient levels of dissolved oxygen do not violate standards. Exchanges of nonconservative pollutants would require a different trading ratio for each pairing of dischargers affecting water quality at a specific location during a specific time period.

[3] Unlike fresh water, sea water has tremendous buffering capacity. Even small amounts of sea water are able to absorb tremendous quantities of acid without measurable increases in pH. For this reason, acid rain is of no concern in marine and estuarine settings.

Finally, the physical characteristics of the problem should be amenable to accurate monitoring. Ease of monitoring was one reason cited by the EPA for the success of the chlorofluorocarbon allowance program as one EPA manager explains:

> I think [incentive-based program approaches] are best designed to fit situations where you are attacking the problems for the first time. I think it's best in a situation where the physical characteristics of the problem allow you to keep track of that which you have permits for readily. The chlorofluorocarbon case was an ideal one because there were not very many manufacturers of chlorofluorocarbons, it's very easy for the government to control the inventory, to know where they came from, how many there were, where the plant was, and so forth (Cook 1988).

At the same time, difficulties in monitoring and defining baseline pollution levels is frequently cited as a significant obstacle to trading in EPA's offset program. Regulators have been reluctant to approve trades where actual baseline emissions information (defined by the historic pollution record of a source) is unavailable. One alternative approach is to use standardized baselines (defined by administrative requirements). However, regulators have been reluctant to use standardized baselines because they could allow firms to create "paper" trades, in which the differences in emissions between those allowed by regulation and those actually emitted by a source, differences which exist only on paper, could be traded against real increases in emissions elsewhere (Cook 1988).

## 5.2 Market Incentives

For a market to emerge, firms must have an incentive to trade. The principal incentive for trading is a difference, between firms, of the marginal costs of meeting environmental protection goals. If trading is to reduce control costs, there must be potential cost savings in a redistribution of reduction efforts among firms. Furthermore, the difference in marginal costs must be of sufficient magnitude to make trading worthwhile. Hahn and Hester (1989b) found that firms used bubbles only where there was potential for large cost savings (upwards of several million dollars per firm). Bubbles that would provide smaller savings were discouraged by the lengthy application process and the low likelihood of approval.

Lack of incentive may be the primary barrier to trading in the acid rain allowance program. Utilities, which are among the most heavily regulated industries in the United States, have found that most avenues to realize profit from trading are blocked at the state level. In some cases, state legislatures have removed the financial incentive for utilities to trade by requiring that all trading profits be returned to rate-payers. Other states prohibit any trades that could cause a loss of productive capacity within the state effectively banning out-of-state sale of allowances. Finally, many Midwestern states have mandated and subsidized costly and inefficient scrubber technologies to protect local coal industries, rather than allowing utilities to switch to low-sulfur western coal.

Theoretically, a trading system should also encourage firms to develop innovative technologies to exceed environmental standards because the costs of technological development can be recouped through permit sales. In practice, however, it appears that this incentive has had relatively little impact. In the SCAQMD, the lack of innovative technologies is probably due to factors such as uncertainty about market price and demand, as well as regulator's tendency to require implementation of any new technology as a technology based standard (Dwyer 1992).

### 5.3 Trading Opportunity

The incentive to trade must be accompanied by the opportunity to trade. The availability of excess tradable reductions is one key to the opportunity to trade. Lack of available permits due to hoarding and the failure of firms to exceed minimum standards were cited as frequent constraints on California's offset trading program (Dwyer 1992). Permit availability also depends on the technological ability of firms to reduce emissions to different levels. If there is just one possible control technology, which can reduce emissions only to a required level, then there will likely be no excess emissions reductions available to trade (Teitz 1994). In cases such as the SCAQMD, where environmental standards are ratcheted downwards, firms may face increasingly limited control options and the availability of excess permits is likely to decrease.

In addition to permit availability, there must be a sufficient number of market players and transactions to produce a clear price signal for a competitive market to function. The number of players is often determined by the geographic scope of the market, which in turn should be defined by the geographic area in which reductions can be traded without compromising environmental objectives. Finally, for cost-effective market prices to emerge, no player must be influential enough to exercise monopoly power (Tietenburg 1990). However, non-competitive markets may still provide savings over no markets at all. If trades occur at all under any conditions, then presumably, some cost savings are being realized through trading.

### 5.4 Transaction Costs

In cases where control costs can be reduced through trading, transaction costs will significantly influence the extent that these potential savings are realized through trading. While transaction costs exist in all markets, their magnitude can vary greatly according to market design. Examples of transaction costs include the costs of finding interested buyers and sellers, the costs of arranging deals, and the costs of regulatory requirements placed on trades. Regulatory costs include requirements -- sometimes mandated by statute -- for firms to conduct studies to quantify reductions or the amount of credits needed to offset certain activities, and the costs of gaining regulatory approval for trades. Dwyer (1993) cited excessive regulatory costs imposed by SCAQMD as one reason for the failure of the offset market in the Los Angeles basin. In contrast, Hahn and Hester (1989a) credited low regulatory and transaction costs as one reason for the success of the lead trading program. In the lead trading program EPA did not insist on pre-approving trades, but simply allowed refineries to report trades to the agency at the end of each quarter.

## 5.5 Uncertainty and Risk

Uncertainty and risk impose additional constraints to the development of permit markets. Uncertainty about the permanence of emissions credits and their value under new regulatory regimes produced a substantial disincentive to trade in the Los Angeles basin offset market. The fear that emission credits could be withdrawn or reduced at the discretion of regulators is frequently cited as a key reason for the failure of the offset market to develop (Hahn and Hester 1989b). In 1990 SCAQMD confirmed industry's fears of regulatory appropriation by discounting most banked credits by 80 percent (Dwyer 1993). As a rule, analysts suggest that property rights must attach to marketable permits for successful markets to emerge, a move SCAQMD and EPA have been unwilling to make.

Uncertainty about the effectiveness of control mechanisms often leads regulators to set high trading ratios to increase the chance that environmental goals will be met through trading. This has been the case in the Lake Dillon PS/NPS trading program where regulators set a 2:1 trading ratio to reflect difficulties in evaluating the success of NPS reductions. Tradeoffs between point and nonpoint sources involve a great deal of uncertainty. While the reasons for uncertainty are many, Letson (1992b) identifies two that stand out. First, limitations in predicting storm driven NPS loadings create difficulties in selecting trading ratios to appropriately substitute for continuous PS discharges. NPS loadings from storm events vary widely and are difficult to predict from ambient loading levels. Second, inadequate monitoring of both PS and NPS loadings adds fuzziness to the "bubble" by allowing dischargers to pollute without purchasing the right to do so. In the Lake Dillon program, both high trading ratios, and the uncertainties of linking specific NPS management actions with actual reductions, have tended to discourage trading.

## 5.6 Legal, Institutional and Political Conditions

Finally, legal, institutional and political conditions must be appropriate for a workable permit trading program to be developed, approved and implemented. At a minimum, the relevant statutory authority must explicitly or implicitly approve a market-based approach. In addition, some political constituency must support implementing marketable permits. To date, most trading programs appear to have been initiated by regulators, affected local groups, or Congress, often as a compromise intended to break political deadlock over expensive environmental programs (Teitz 1994). The support of regulatory agencies is especially critical when there is no explicit statutory for trading programs because only regulatory agencies are able to claim that implementing trading programs is within their mandate to exercise discretion (Teitz 1994).

The support of both the regulated industries and public interest or environmental groups is often critical to the success of trading programs. In the two most ambitious programs to date, RECLAIM and the acid rain program, environmental groups were instrumental during the program design stage and lobbied for program approval (Dwyer 1993). If industry and environmental groups are to form active constituencies, both must view marketable permit programs as advancing their respective agendas. Both groups are most likely to advocate trading when they believe it is the best outcome they are likely to get (Hahn 1989a). Unfortunately this may become apparent only after advocacy groups have spent years battling each other to a standstill as happened with acid rain.

## 6 CONCLUSIONS

A wide range of marketable permit programs are currently active in the United States. Many levels of government have instituted incentive-based programs from individual towns to the Federal Government. Although it would be desirable to be able to summarize the cost savings from their use, the financial consequences to individual economic sectors, and the environmental effects of each of these programs, the available evidence provides significant information only on the cost savings. To date, over 20 quantitative comparative studies have been done, all of which indicate that marketable permits should be much more economically efficient than command-and-control approaches for controlling environmental pollution (EPA 1992). The differences in economic efficiency are potentially quite large. However, due principally to constraints placed on trading, many studies also conclude that the actual cost savings realized by current programs fall well short of the potential indicated by these comparisons.

Although incentive-based programs are being used increasingly, they are not always implemented with the sole objective of decreasing costs. Consequently, the cost savings have often fallen short of what would have been possible. Among the market-based trading systems with which there is experience, the lead trading program came closest to achieving the projected cost savings. Most other emission and effluent trading systems have been subject to severe regulatory constraints that have raised barriers to trading. As policy-makers begin to examine the use of marketable permits as a solution to other environmental management problems such as fisheries bycatch regulation, these results underscore the importance of assuring that unnecessary constraints are not imposed in future trading applications.

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