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DAVID LETSON\*

# Point/Nonpoint Source Pollution Reduction Trading: An Interpretive Survey

## ABSTRACT

*Nonpoint source water pollution controls may be necessary if the objectives of federal water pollution control legislation are to be met. Control of nonpoint sources is more likely to be cost effective if imposed in a decentralized manner. One option for expanding the regulatory scope to include nonpoint sources is to allow trading of discharge reductions between point and nonpoint sources. A body of research and experience suggests a capability for this policy alternative to lower control costs, but we know less about important issues such as monitoring costs, market power, distributive effects, incentives for innovation, and nonconservative pollutants.*

## INTRODUCTION

Nonpoint source water pollution controls may be necessary if the objectives of federal water pollution control legislation are to be met.<sup>1</sup> Control of point source discharges since 1972 has yielded some improvements in the nation's water quality. Problems with conventional pollutants such as bacteria and oxygen-demanding waste have lessened.<sup>2</sup> Unfortunately, the quality of the nation's surface waters has not improved commensurately with these point source reductions.<sup>3</sup> States continue to report to the Environmental Protection Agency that significant portions of waterways remain unfit for designated uses. Nonpoint source contributions

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1. Exactly how nonpoint source controls would be imposed and who would pay for them remain contentious issues; however, this realization itself is hardly new. See, e.g., United States Comptroller General, National Water Quality Goals Cannot Be Attained without Attention to Pollution from Diffused or "Nonpoint" Sources, Rep. CED-78-6 (1977).

2. United States Environmental Protection Agency (EPA) Office of Water, National Water Quality Inventory: 1988 Report to Congress EPA 440-4-90-003 (1990).

3. R. Smith, R. Alexander & M. Wolman, *Water Quality Trends in the Nation's Rivers*, 235 Sci. 1607 (1987).

remain and have increased as a share of the problem. Impairments such as sedimentation, nutrient enrichment, runoff from farmlands, and toxic contamination of fish tissue and sediments have become more evident.<sup>4</sup>

Nonpoint sources have grown as a share of the water quality problem because they are harder to identify and control than point sources. Nonpoint source contributions depend upon localized features such as land uses, climate, and geology. Control of nonpoint sources is more likely to be cost effective if imposed in a way that allows for their site-specific nature. One way of dealing with these institutional problems would be to allow point sources to sponsor implementation of nonpoint source controls rather than install further controls of their own.<sup>5</sup> Point source operators may be better situated to identify and manage localized water quality problems than distant regulators can be, and point/nonpoint trading perhaps would give them incentive to do so. Dillon and Cherry Creek Reservoirs in Colorado have programs of this type, and another for the Tar-Pamlico River basin in North Carolina has recently appeared.<sup>6</sup> This

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4. EPA, *supra* note 2.

5. Some statutory authority exists that allows states to pursue market-based approaches to nonpoint source pollution problems. Section 319(h)(5) of the 1987 amendments to the Clean Water Act (33 U.S.C. §§ 1251-1387 (1987)) gives EPA the authority to direct grants for "innovative and alternative approaches for the control of nonpoint sources of pollution." Congress is currently revising the Clean Water Act and is considering adding language that would explicitly allow, promote, or require states to consider this type of policy. The objective of including such language would be to help overcome real and perceived institutional barriers for adoption. *See*, E. Bartfeld, *Point/Nonpoint Source Trading: Looking Beyond Potential Cost Savings*, master's thesis School of Natural Resources, University of Michigan, Ann Arbor (April 1992).

6. Point/nonpoint source trading programs are in their formative stages and as yet have not produced economically motivated trading. The Tar-Pamlico program began in December 1989 and has not yet produced any trading. Two reasons can be cited. First, the lack of a nutrient model for the basin means that the state and dischargers do not have accurate information about the basin's water quality dynamics. Second, the basin's point sources are likely to pursue inexpensive internal modifications to achieve mandated reductions rather than trade. Apogee Research for EPA, *Incentive analysis for CWA Reauthorization: Point/Nonpoint Source Trading for Nutrient Discharge Reductions* (April 1992) (unpublished report on file with EPA's Office of Water, Washington, D.C.); Telephone Interview with G. Anderson, economist, North Carolina Environmental Defense Fund (Apr. 10, 1991). At Dillon Reservoir, improved operating efficiency of existing tertiary treatment technology has greatly reduced point source discharges and the need for phosphorus credits. One point/nonpoint trade has occurred, but not as a result of the trading incentive. The Breckenridge Sanitation District extended a sewer line to a subdivision whose septic systems were failing. The Dillon program does operate as a framework for offsetting new nonpoint sources of phosphorus with reductions, however. Two other nonpoint source control projects have been built and are being monitored for their removal capabilities; credits from them may be used by treatment plants or to offset new nonpoint source loads. The first is a stormwater drainage/settling system built by the community of Frisco in exchange for a credit on its planned golf course. The second involves a detention structure for the tributary Soda Creek, to offset the contribution of another creek which the Denver Water Board wishes to divert into Dillon. Telephone Interview with L. Wyatt, engineer, N.W. Colo. Council of Gov'ts (Feb. 5, 1991). The Cherry Creek Reservoir program calls for a 50 percent reduction in phosphorus loadings before nonpoint source reductions can be traded for point source ones; thus trading activity is probably a couple of years away. Telephone Interview with J. Kempfer, Manager of the Cherry Creek Basin Authority (Feb. 5, 1991). An amendment that would have included point/nonpoint

paper will describe point/nonpoint source trading and what we know about its potential for lowering control costs and bringing nonpoint sources under control.

Point/nonpoint source trading is the bubble idea applied to watershed management. A "bubble" (or "bowl" for a watershed) sums the emission levels for all sources included in the bubble and allows adjustment of the levels of control applied to each so long as the total does not exceed a target aggregate emission level.<sup>7</sup> Specifically, point/nonpoint source trading has come to mean granting publicly-owned treatment plants and industrial point sources the option of bringing agricultural and urban nonpoint sources under control rather than simply requiring further controls at the point sources. The regulator continues to focus on the more easily identified and managed point source; but grants them more flexibility to pursue lower cost control options.<sup>8</sup>

Soil conservation efforts aside, experimentation with incentive policies such as point/nonpoint source trading has not been commonplace in water quality regulation. Technology-based point source regulations arguably were a logical first step in 1972.<sup>9</sup> Industrial and municipal point sources were the worst and most obvious offenders of surface water quality. They were also the easiest to address because their loadings emerge from a discrete point such as the end of a pipe. Nonpoint source problems are harder to manage because monitoring and enforcement become more difficult when sources are diffuse. Markets for pollution reductions for water quality have lagged behind those for air (since 1974) partly because of the greater contribution of difficult to manage nonpoint sources.

Despite these institutional problems, we may now be at a stage where nonpoint source reduction in many instances is less costly than further point source controls. Thus the 1987 amendments to the Clean Water Act call for state watershed management strategies to reduce nonpoint source pollution. Section 319 (b)(4) of the 1987 amendments understandably

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source trading as part of the 1990 reauthorization of the Coastal Zone Management Act was defeated last year in Congress. Also, the Vermont Water Resources Board has advocated consideration of point/nonpoint source trading for phosphorus management in the Lake Champlain basin. The technical advisory for the Lake Champlain Management Conference that will develop a comprehensive pollution prevention, control, and restoration plan by 1993, is also considering point/nonpoint source trading. Telephone Interview with F. Lowenstein, Director of the Lake Champlain Committee (Feb. 5, Dec. 11, 1991).

7. Actually, point/nonpoint source trading as implemented more closely resembles "offsets," which allow a firm to create a new source in an area not currently meeting standards to it if the firm can reduce emissions elsewhere in the area. The "bubble" concept is a general one and much better known, however; the comparison with it is not a misleading one.

8. The fairness of achieving nonpoint source control at the expense of point sources is open to question, however. The distributive implications of point/nonpoint source trading are largely unexplored.

9. See B. Ackerman & R. Stewart, *Reforming Environmental Law*, 37 Stan. L. Rev. 1333, 1365 (1985).

allows states to design management plans on a watershed-by-watershed basis.<sup>10</sup> Policies more flexible than national technology-based standards may be necessary to manage nonpoint source problems, which are characteristically site-specific. In theory and perhaps in practice point/nonpoint source trading can help achieve nonpoint source control and lower total control costs in the process.

The trading of pollution rights is not itself a novel idea, but its application to nonpoint source water pollution is. This paper is an interpretive survey of the research into, and practical experience with, point/nonpoint source trading.<sup>11</sup> In the next section a short discussion presents the case for point/nonpoint source trading and offers a reminder that point/nonpoint source trading, whatever its cost saving potential, will not avoid fundamental limitations of any approach for achieving nonpoint source control. Point/nonpoint source trading will escape neither the cost savings/water quality tradeoff nor the problems posed by limitations in our ability to predict, monitor, and control nonpoint source loadings. It would, however, resolve some problems because it allows voluntary redistributions of discharge rights and encourages site-specific management of water quality problems. Even this brief discussion is able to raise the empirical questions which underlie the broader question of how useful the point/nonpoint source trading approach might be. A third section considers these issues and others in more detail. The body of research and experience suggests a capability for this policy alternative to lower control costs, but we know less about important issues such as monitoring costs, market power, distributive effects, incentives for innovation, and the types of water quality problems for which the approach is feasible. The concluding remarks suggest some directions for further research.

### THE ECONOMICS OF POINT/NONPOINT TRADING: THE RATIO "T"

A short discussion of the economics of point/nonpoint (PS/NPS) source trading helps show both its appeal and some difficulties in its application.

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10. 33 U.S.C. §§ 1251-1387 (1987).

11. Several related reviews exist. K. Segerson, *Incentive Policies for Control of Agricultural Water Pollution*, in *Agriculture and Water Quality* 39-62 (J. Braden & S. Lovejoy eds., 1990) provides a more general survey of incentive policies that could be used for agricultural water pollution control. K. Reichelderfer, *National Agroenvironmental Incentives Programs: the U.S. Experience*, *Id.* at 131-46, surveys the United States experience with incentive policies for control of agricultural water pollution control. Apogee Research for EPA, *supra* note 6, describes the design and performance of programs that use trading between point and nonpoint sources to control nutrients, and presents the available evidence assessing the potential scope for their successful implementation nationally. Bartfeld, *supra* note 5, focuses on design of PS/NPS trading programs within the language of the Clean Water Act. M. Griffin, W. K. Kreutzberger, and P. Binney, *Research Needs for Nonpoint Source Impacts*, 3 *Water Envir. and Tech.* 60 (1991) identify knowledge gaps that make NPS pollution control more costly and less reliable.

The randomness of nonpoint source loadings makes them difficult to predict. Our ability to monitor and control these loadings once they occur is also less than perfect. More fundamental still is the tradeoff between cost savings and water quality that no policy will avoid. In addition, application of PS/NPS trading would likely be more difficult if the pollutant is one that decays. These issues are central to evaluating the potential of PS/NPS trading to bring NPSs under control.

PS/NPS trading has potential if cheap NPS reductions exist and are similar enough in nature to the PS reductions they would replace. Thus the usefulness of PS/NPS trading for bringing NPSs under control depends on two related considerations. The first is a requirement that NPS control should be a cheaper way of achieving water quality objectives than further PS reductions. Sewage treatment plants, for example, are unlikely to sponsor nonpoint source control measures (for example, conservation tillage or sedimentation ponds) as a means of avoiding technology upgrades at their own sites unless doing so saves them money. Existing empirical studies suggest that this condition holds for at least some sites.<sup>12</sup> An early study of the Honey Creek watershed in Ohio finds potential savings are small and depend on the level of reliability desired, the capacity of the treatment plant alternative, and the level of phosphorus removal. If the removal target is 25 percent and 50 percent reliability is acceptable, then the estimated savings range from -0.3 to 8.84 1985 dollars per pound removed, depending upon capacity of the treatment plant alternative. With higher reduction levels, higher desired reliability, or treatment plant capacities greater than 10 million gallons per day, removal at the treatment plant is cheaper than the conservation tillage alternative.<sup>13</sup> Larger potential savings occur in the Industrial Economics case study of the Wicomico basin in Maryland. Trading provides annual savings of 64,000 1985 dollars (83 percent) in meeting a 25 percent reduction level and \$245,000 (35 percent) in meeting a 75 percent reduction target.<sup>14</sup> Unfortunately no study of cost effectiveness exists that would complement these case studies by providing insights on the national level, where many environmental policy decisions are made.

The second consideration is that costly uncertainty stemming from the prediction, monitoring, and control of NPS loadings should not overwhelm the possible savings. The regulator must find an acceptable balance

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12. See, e.g., Report by DPRA Inc. for EPA, An Evaluation of the Cost Effectiveness of Agricultural Best Management Practices and Publicly Owned Treatment Works in Controlling Phosphorus Pollution in the Great Lakes Basin (1986) (unpublished report on file with EPA's Office of Water, Washington, D.C.). See also Report by Industrial Economics for EPA, Point/Nonpoint Trading to Reduce Phosphorus Loads to Chesapeake Bay: the Wicomico Case Study (1987) (unpublished report on file with EPA's Office of Water, Washington, D.C.).

13. DPRA, *supra* note 12.

14. Industrial Economics, *supra* note 12.

between the objectives of reducing control costs and achieving water quality objectives with reliability. Not surprisingly, the potential of PS/NPS trading depends on an evaluation of the familiar cost savings/water quality tradeoff in an uncertain setting. Much of this potential boils down to a social willingness to accept uncertainty in return for control cost savings.

While the existence of savings is an easy enough idea, the cost savings/water quality tradeoff is not. The issues the regulator must consider in accepting NPS reductions for PS ones are several and complex. The cost savings/water quality tradeoff is inherent in the regulator's most important policy variable, the trading ratio "t." The regulator will accept a unit reduction of the pollutant at a NPS only as a  $1/t$  units credit toward avoided control at a PS. In other words, the trading ratio gives the number of units of NPS loadings reduction a PS must sponsor to avoid reducing its own loadings by a unit. The trading ratio is an adjustment to allow for the differences in the nature of PS and NPS loadings and in the tasks of regulating them. In the simplest sense the ratio can be thought of as an adjustment reflecting the differences in marginal social costs posed by the two types of sources. In particular, NPS loadings are less predictable temporally and spatially because they are more random than PS loadings; are less reliably controlled than PS controls; and in the case of phosphorus produce a form that is less biologically available than that yielded by wastewater effluent.<sup>15</sup>

The regulator selects the trading ratio so that the PS's decision whether to engage in a trade will reflect the full social costs of each type of reduction. Consider the value of one as a benchmark.<sup>16</sup> If the regulator sets the trading ratio greater than one, then it is favoring PS reductions and discouraging trading by making PSs create more than one unit of NPS reduction in order to avoid its own unit reduction. As an extreme example, one could consider the absence of PS/NPS trading to be a policy setting the trading ratio prohibitively high. A policy setting the trading

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15. A formal discussion of this ratio containing explicit consideration of many of these issues is presented in D. Letson, S. Crutchfield & A. Malik, *Point/Nonpoint Source Trading for Controlling Pollutant Loadings to Coastal Watersheds: A Feasibility Study* (forthcoming in *The Management of Nonpoint Source Pollution* (C. Russell & J. Shogren eds.)). See also J. Shortle, *Allocative Implications of Comparisons Between the Marginal Costs of Point and Nonpoint Source Pollution Abatement*, 16 N.E.J. Agric. & Resource Econ. 17 (1987). The seminal economic model of regional water quality management is W.D. Montgomery, *Markets in Licenses and Efficient Pollution Control Programs*, 5 J. Econ. Theory 377 (1972).

16. The choice of one is for explicatory purposes. Values less than one are unlikely given Section 402(o) of the Clean Water Act, the antibacksliding provision, which discourages discharge permit revisions that do not reduce total daily loadings of pollutants to a watershed. Bartfeld, *supra* 5. Tar-Pamlico uses trading ratios of 3 and 2 for cropland, and animal waste loadings reductions, while Dillon Reservoir uses a single trading ratio equal to 2.

ratio greater than one may be well-advised if PS reductions are less costly to achieve and enforce, if the performance of NPS controls are highly uncertain, or if PS loadings are more damaging than those from NPSs. Also, the value of the trading ratio should reflect any interdependence between PS and NPS loadings. More sewer hookups, for example, usually mean not only greater PS discharges at the sewage treatment plant but also greater NPS loadings indirectly through the additional development they allow. If more PS loadings imply more NPS loadings, then higher values for the trading ratio are appropriate.<sup>17</sup> Conversely, a policy setting the trading ratio less than one would favor NPS reductions and encourage trading. A PS could avoid a unit reduction with less than a unit of NPS reduction. Such a policy would be well-advised if NPS reductions are less costly to achieve and enforce or if NPS loadings are more damaging than those from PSs.<sup>18</sup>

How much trading will occur depends on considerations besides cost that the regulator should consider in selecting its trading ratio. Tradeoffs between point and nonpoint sources involve uncertainty. Trading and cost savings are unlikely to occur if NPS control is so uncertain that it can only minimally substitute for PS control. The reasons for this uncertainty are many, but two stand out. Limitations in predicting storm-driven NPS loadings imply difficulties in selecting the trading ratio that would appropriately substitute continuous PS loadings for them. Inadequate monitoring adds fuzziness by allowing dischargers to pollute without purchasing the right to do so. In addition, federal and state policies may conflict with the local incentive policy. USDA crop price and income support programs, for example, inadvertently affect water quality and might present such an obstacle.

A trading ratio that would achieve both savings and reliable water quality will not exist for many watersheds. To increase the chance that water quality goals will be met despite the less-proven and more uncertain performance of NPS controls, the regulator may choose to set a high trading ratio. Such a policy would require larger NPS reductions to free up PSs from their requirements. The case study of the Honey Creek basin in Ohio explores many of these issues in comparing the cost effectiveness of best management practices for agriculture versus phosphorus removal by sewage treatment plants.<sup>19</sup> In that study, reliability greater than a 50 percent chance of instantaneous compliance with the nutrient standard

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17. This interdependence was one of the reasons why a ratio of 2 was selected for Dillon Reservoir Apogee Research for EPA, *supra* note 6.

18. Letson, *supra* note 15.

19. See DPRA, *supra* note 12. See also J.W. Milon, *Optimizing Nonpoint Source Controls in Water Quality Regulation*, 23 *Water Resource Bull.* 387 (1987).



would come only at the expense of any cost savings. The ability of PS/NPS trading to bring NPSs under control depends on the availability of a value for the trading ratio that would satisfy both cost and reliability objectives.

Not all limitations in practice for PS/NPS trading are inherent in the regulator's choice of a single trading ratio. The potential of PS/NPS trading to achieve NPS control also depends on the number of NPS problems where it could be successfully applied. Point and nonpoint sources do not always discharge the same pollutants. Point (bacteria and oxygen-demanding waste) and nonpoint (sedimentation and nutrient enrichment) sources are often responsible to different degrees for different types of water quality problems, so PS/NPS trading can probably at best be only part of a solution for NPS related impairments. Also, extension of PS/NPS trading beyond nutrient control is difficult because many pollutants are nonconservative (degradable). An acceptable answer to the "t" question here would require us to consider the time dimension of decay during transport. Regulation of nonconservative pollutants such as biochemical oxygen demand requires the staggering of discharges by time and location so that ambient constituent levels (of dissolved oxygen, for example) do not violate standards. Formally, a different trading ratio would exist for each pairing of two dischargers with a water quality problem location; a trading ratio would reflect the relative impacts of the sources' discharges upon, say, dissolved oxygen at the water quality problem location. Not surprisingly the PS/NPS trading programs in place involve conservative pollutants (for example, phosphorus) in waterbodies that are not regularly flushed out. Water quality problems that include nonconservative pollutants are more uncertain and more politically charged. Trading programs are simpler and more appealing when the pollutant is one that causes its trouble by accumulating. One last problem is that ordinarily we cannot consider surface and ground water quality separately. Ground water recharge and leaching will occur and may significantly vary with trading activity. Offsetting these effects might prove difficult.

Some of these problems are fundamental to PS/NPS trading and thus unavoidable. Selection of a conservative pollutant does not eliminate all uncertainty, the sources of which are many. Our ability to monitor NPS loadings is still limited since polluting actions are often unobservable and we cannot infer them individually from ambient pollution levels.<sup>20</sup> Prediction of loadings is difficult because NPS pollution is largely storm-driven. We still have much to learn about physical systems and how well pollution control systems work. A large physical modeling effort is nor-

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20. K. Segerson, *Uncertainty and Incentives for Nonpoint Point Pollution Control*, 15 *J. Envtl. Econ. Mgmt.* 87 (1988).

mally required to establish target loadings and boundaries for the watershed. The permits must be initially distributed in some way; methods based on past discharge levels are more politically salable but require information on historical practices that generally is not available for NPSs.

All these problems make PS/NPS trading less reliable than PS controls. A value for the trading ratio that would achieve water quality objectives and preserve some control cost savings may not exist. Designing a PS/NPS trading policy that would lower actual costs and achieve NPS control (formally, the choice of  $t$ ) involves the familiar tradeoff between cost savings and water quality in an uncertain setting. At issue is the existence of a social willingness to accept uncertainty in return for control cost savings. Even a brief verbal description of PS/NPS trading raises many questions about its ability to achieve its potential savings.

### RESEARCH ISSUES

While PS/NPS trading has its problems, it is worthy of further attention for two reasons. First, problems exist for any approach that might achieve NPS control on a large scale. Most of the problems described above will afflict any attempt to control NPSs. Traditional pollution control policies applied to NPSs would have some additional problems of their own. Regulations would be difficult if not impossible to apply to site-specific NPSs. Expanded use of voluntary methods such as cost sharing or technical assistance could carry a heavy federal price tag. Decentralized trading at least would handle the question of who would pay. This is no small matter, as economic theory tells us that pollution problems are property rights disputes. The 1987 amendments to the Clean Water Act call for NPS control, but Congress has provided only a small amount of funding (\$143.75 million), for the most part leaving states with the bill.<sup>21</sup> Second, the potential to save control costs does seem to exist.<sup>22</sup> What remains to be shown is that the potential control cost savings outweigh the uncertainty of trading. Ironically, the evidence that would suggest this is usually or ever the case would be successful PS/NPS trades, and few exist. Success of PS/NPS trading will depend on its application to a broader range of pollutants, improved policy design, and better enforcement. A listing of associated research issues and needs follows.<sup>23</sup>

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21. Fiscal Year 90 Congressional Appropriation was \$40 million; \$51 million in FY91 (EPA, Managing Nonpoint Source Pollution: Final Report to Congress on Section 319 of the Clean Water Act, EPA-506/9-90 at 8 (Apr. 1991)); and \$52.75 million in FY92 (Telephone Interview with A. Weinberg, EPA Office of Water, Nonpoint Source Control Branch (Feb. 21, 1992).

22. DPRA and Industrial Economics, *supra* note 12.

23. This listing follows the outline of T. Tietenberg, *Emissions Trading: An Exercise in Reforming Pollution Policy* (1985).

(1) Potential to save control costs. Case studies have provided examples where the potential of PS/NPS trading to reduce control costs exists.<sup>24</sup> In addition, the local regulatory authorities had established the cost saving potential of the two trading programs in place in Colorado before proceeding with implementation.<sup>25</sup> More case studies would give a better picture of the prospects of PS/NPS trading in different geographic regions. That little trading has occurred at the three sites, however, despite the possible savings, is somewhat disturbing and suggests that potential control cost reduction alone may be a moot point.

(2) The spatial dimension. Successful extension of PS/NPS trading to nonconservative pollutants would enhance its ability to bring NPSs under control. As noted above, the PS/NPS trading programs in place regulate conservative pollutants. Inorganic phosphorus does not decay, and its total quantity determines its harmfulness. Nonconservative pollutants, biochemical oxygen demand for example, present more of a problem. The timing and location of their discharge are as important as their quantity. A trading program that limited only the total quantity of discharges might well allow some areas to be in violation if the pollutant is non-conservative. One solution, unexplored in the existing literature, would be to adjust the trading ratio to allow for decay rates. Another spatial problem concerns the nutrient cycle in an estuary, where (a) multiple nutrients may interact and (b) the limiting nutrient may vary by season.<sup>26</sup> These problems require a more extensive physical model and, with our limitations therein, probably are feasible for small scale regulatory efforts only.<sup>27</sup>

(3) Distributing the financial burden. The existing literature on PS/NPS trading has not considered its distributive effects. Virtual unanimity exists, among those who have studied the cost incidence of stationary source air quality regulations, that command and control regulations (those that specify the methods and technologies dischargers must use to control pollutants) are regressive.<sup>28</sup> Higher product prices transmit the burden of regulation disproportionately to the poor, who spend a higher percentage of their incomes on affected commodities than do the rich. The same might occur if the initial financial burden for agricultural NPS controls

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24. DPRA & Industrial Economics, *supra* note 12.

25. R.W. Hahn & G.L. Hester, *Where Did All the Markets Go?*, 6 Yale J. Reg. 109 (1988).

26. A. Krupnick, *Tradable Nutrient Permits and the Chesapeake Bay Compact* (unpublished Future Discussion Paper QE89-07, on file with Resources for the Future, Washington, D.C.) (1989).

27. J.A. Antle & S. Capalbo, *Measurement and Evaluation of the Impacts of Agricultural Chemical Use: A Framework for Analysis* (unpublished Resources Future Discussion Paper FAP90-09 on file with Resources for the Future, Washington, D.C.) (1990).

28. See, e.g., L. Gianessi, H. Peskin & E. Wolff, *The Distributional Effects of Uniform Air Pollution Policy in the United States*, 93 Q. J. Econ. 281 (1979). See also H. Robison, *Who Pays for Industrial Pollution Abatement?*, 67 Rev. Econ. Stat. 702 (1985).

fell on farmers, since they would likely be able to pass some of these costs on to consumers, depending upon price elasticities of supply and demand for agricultural commodities. Policy makers might need to devise transfers to offset any undesirable distributive effects.

Initial allocation of permits is another important distributive issue. Much of the appeal of PS/NPS trading for policy makers is that it need not redistribute discharge rights but allows voluntary trades that will. Alternative methods of initial distribution might ease entry and exit for the affected product markets, making them more competitive, but would redistribute rights and would be coercive and costly for agricultural producers and urban areas.

Distributive analysis is also important because the distributive and allocative effects of trading are not altogether separable. Another advantage of trading programs is what Tietenberg calls "cost sharing": the party carrying out the reduction is not necessarily the one paying.<sup>29</sup> Conventional command and control policies are often slow to impose controls because of a political reluctance to bankrupt businesses. Tradable permit programs, then, can go into effect faster since they are less likely to put firms out of business than nontradable permit programs. Also, command and control policies can significantly influence industry structure. An undesirable side effect of most air pollution controls, for example, is that they affect only new sources and thus act as a barrier to the entry of new firms, retarding capital turnover.<sup>30</sup>

(4) Market power. Two areas of concern exist. (a) Could a single discharger or a group of them attain enough control over a permit market to extract large transfers from other participants? (b) How would the change to PS/NPS trading affect the degree of competitiveness in product markets? We have more theoretical than empirical evidence on both questions. Malueg, for example, shows how introduction of permit trading in regions where firms participate in noncompetitive output markets may reduce social welfare.<sup>31</sup>

On the first question, it is easy to show that permit price manipulation might produce some transfers, but because all parties would share in them, significantly higher control costs are unlikely.<sup>32</sup> As for the second question, seldom do most of the participants in a product market coexist in a single watershed. Tietenberg's example is the Piceance Basin in Colorado, which produces most shale oil. As he notes, however, even

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29. Tietenberg, *supra* note 23.

30. M.T. Maloney & G.L. Brady, *Capital Turnover and Marketable Pollution Rights*, 31 J. Law Econ. 203 (1988).

31. D. Malueg, *Welfare Consequences of Emissions Credit Trading Programs*, 18 J. Envtl. Econ. Mgmt. 66 (1990).

32. *See, e.g.*, Tietenberg, *supra* note 23, at 127-28.

these producers face competition from other types of energy.<sup>33</sup> Misiolek and Elder offer the dissenting view, arguing that some firms might try to manipulate the permit market to raise the costs of other firms and increase their own monopoly power.<sup>34</sup>

(5) The temporal dimension. Here is another opportunity to broaden the range of problems for application of PS/NPS trading. Permit design can allow for temporally varying (for example, diurnal or seasonal) assimilative capacity. Periodic permits can manage predictable, short-term peaks brought about by seasonal or diurnal variations in meteorological conditions. Nonconservative pollutants whose rates of decay are temperature or flow dependent might be candidates for this approach. Episodic permits can manage pollution in the rare, but potentially devastating instances that are predictable only a day or so in advance, such as thermal inversions.<sup>35</sup>

(6) Enforcement. NPS loadings are difficult to measure, and therefore regulations for them are difficult to enforce. PS/NPS trading can do little to alleviate this problem. Perhaps PS/NPS trading will become a more attractive option as monitoring technology improves, but perhaps not. To some extent we can observe and enforce behavior that reduces NPS loadings. For example, USDA requires approved conservation practices on highly erodible land. If we could establish stronger linkages between activities and pollution, environmental policies would be more effective and enforcement would be easier. Regulators could verify many control options (reduced tillage, no till, and crop rotations, for example) by observation.

The enforcement problem is complex and multi-dimensional; at least three other areas deserve attention. (a) Cost minimizing behavior of firms involves weighing the costs of compliance versus the costs of seeking relaxed standards; the latter include the costs of lobbying, litigation, negotiation, legal defenses, and penalties.<sup>36</sup> Policies should minimize total costs, not just control costs. (b) The focus of enforcement under command and control regulations has been on initial compliance at the expense of continuing compliance; the two are different sides of the same problem. Malik shows how noncompliance can limit the efficiency of a permit trading program.<sup>37</sup> (c) Limitations in monitoring pollution control efforts

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33. Tietenberg, *supra* note 23, at 140-41.

34. W. Misiolek & H. Elder, *Exclusionary Manipulation of Markets for Pollution Rights*, 16 J. Envtl. Econ. Mgmt 156 (1989).

35. J.W. Eheart, E.D. Brill, B. Lence, J. Kilgore & J. Uber, *Cost Efficiency of Time-Varying Discharge Permit Programs for Water Quality Management*, 23 Water Resource Res. 245 (1987).

36. Ackerman, *supra* note 9.

37. A. Malik, *Markets for Pollution Control When Firms Are Noncompliant*, 18 J. Envtl. Econ. Mgmt. 97 (1990).

would reduce accuracy in verifying reductions, creating an incentive to pollute.<sup>38</sup> Cost efficiency and water quality might suffer as a result.

(7) Incentives for innovation. PS/NPS trading would provide long run incentives for innovation since dischargers would have alternatives for achieving mandated reductions. Because PS/NPS trading programs can draw only from their watersheds for participants, the magnitude of this incentive is less than for EPA emissions trading programs, for example, some of which are more extensive geographically. Even if small, incentives for innovation can be important. The state of pollution control technology is one set of boundaries for environmental policy design. Kneese and Schultze have described the effects of regulation on the pace of technological advance in pollution control as "perhaps the single most important criterion on which to judge environmental policies."<sup>39</sup> Arguably, we should judge PS/NPS trading by its ability to achieve long run rather than short run savings and NPS control.

Most of the literature in this area has focused on firm incentives to develop firm-specific technologies. Recently, Milliman and Prince broadened the scope of these issues somewhat, describing three different phases of technological change: innovation, diffusion, and optimal agency response. In their more general framework, cost effective control requires promoting innovations with inter-firm applicability, encouraging the diffusion of new technologies, and recognition by the regulatory agency of the lower costs implied by the new technology.<sup>40</sup> Benefits from such long-term planning might exceed those from short-term control cost reductions.

### CONCLUDING REMARKS

Given these institutional problems it is easy to be pessimistic about the prospects for PS/NPS trading. On the other hand, no obvious alternative exists for achieving NPS control on a large scale. NPS water pollution controls may be necessary if the objectives of federal water pollution control legislation are to be met. If so, we will need policies more flexible than national technology-based standards to manage NPS problems, which are characteristically site-specific. This paper has provided an interpretive survey of the research into and the practical experience with PS/NPS trading. It has sought to assess the capability of PS/NPS trading for achieving control cost savings and bringing NPSs under control.

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38. Hahn, *supra* note 25.

39. A. Kneese & C. Schultze, *Pollution, Prices and Public Policy* 82 (1978).

40. S. Milliman & R. Prince, *Firm Incentives to Promote Technological Change in Pollution Control*, 17 *J. Envtl. Econ. Mgmt.* 246 (1989).

PS/NPS trading is an idea whose time has not yet come for national policy. Whether the potential to achieve cost savings and NPS control will exist in the future is a question for further research. An applicability to a broader range of pollutants and an ability to induce innovation might make PS/NPS trading more attractive. We know something about the capability of the policy to reduce control costs, but less about its administrative ease. Little is known about its ultimate distributive effects or the influence of market power. Perhaps the most vexing complication is the all too familiar difficulty of monitoring NPSs. If we cannot measure NPS reductions, we will hardly be able to form a market for them. Unfortunately, monitoring problems, like many others discussed here, would afflict almost any NPS control policy. Since we have no easy or cheaper alternatives for achieving NPS control on a large scale, PS/NPS trading remains worthy of our attention.

The scope of further research will also be important because policy decisions will be made at all levels of government. Case studies can capture the site-specific characteristics of each problem (for example, climate, land and water uses, and geophysical characteristics of a watershed) and can lend themselves to regional inferences. Trading programs should vary geographically because water quality problems do. Such studies would contribute more if they could address the broader range of issues outlined above rather than merely assessing control cost reduction potential. The cost effectiveness of prevention (conservation tillage, for example) as opposed to treatment (detention basins) is also worth examining. A national picture could emerge only from several more of these studies, however. Alternatively, national assessment of the number of opportunities for such a policy would lose such site-specific detail but would bring the level of analysis to where many policy decisions are made. Shabman and Norris do this on a state level, offering a useful list of "selection criteria" for determining the number of possible PS/NPS trading sites in Virginia.<sup>41</sup> Letson, Crutchfield, and Malik use a similar approach to screen for coastal watersheds that could participate in a hypothetical national program.<sup>42</sup> Case studies and a national assessment together would give a better assessment of the potential of PS/NPS trading to reduce control costs and achieve NPS control.

Showing the control cost reduction potential of PS/NPS trading was the easy part; the real case to be made for PS/NPS trading, through research and documentation of existing programs, is that it can surmount the problems discussed here and create the institutional structure for NPS control.

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41. L. Shabman & P. Norris, Coordinating Point and Nonpoint Control of Nutrient Pollution: Prospects for a Virginia Case Application (unpublished Virginia Tech Department of Agricultural Economics Working Paper 39-87-1).

42. Letson, *supra* note 15. See also Apogee Research for EPA, *supra* note 6.