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Water Quality Credit Trading and Agriculture: Recognizing the Challenges and Policy Issues Ahead

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Economists have long championed market-based approaches over regulatory "command and control" approaches for addressing environmental problems. Recently, federal and state policymakers and some stakeholder groups have promoted market-based approaches for dealing with agricultural water pollution. At the federal level, the U.S. Environmental Protection Agency (US EPA) in 2003 issued a trading policy that allowed industrial and municipal point sources (PS) to meet their discharge requirements through purchase of "credits" from farmers and ranchers who implemented conservation measures that improved water quality. In October 2006, US EPA and the U.S. Department of Agriculture (USDA) reached an agreement to establish and promote water quality credit trading. In January 2007, USDA Secretary Johanns stated that in the upcoming farm bill, the administration will view market-based solutions as an important tool in federal environmental protection efforts aimed at agriculture (USDA, Natural Resources Conservation Service, 2007). At the state level, Idaho, Michigan, Ohio, Oregon, Pennsylvania, and Virginia have enacted laws or created regulatory programs to encourage water quality trading (see the summary of state efforts in ETN, 2007).

Given these activities, what can realistically be expected from market-based programs, and specifically water quality credit trading, in addressing the difficult issue of water pollution from agriculture? We conclude that policymakers are expecting far too much from trading as a tool to address agricultural nonpoint source (NPS) water pollution. Currently, water quality credit trading in agriculture is in its infancy and significant implementation challenges exist. Trading program design and implementation must address complex physical, social, economic, legal and public policy issues. This will require more exchange among economists, policymakers, farmers, municipalities, and other stakeholders than is currently occurring. Only then will trading as a potential tool be fully understood and appropriately implemented.

In a previous issue of *Choices*, King (2005) examined issues encountered by water quality trading programs. We observe that changes in conditions affecting the supply and demand sides of potential water quality credit trading markets suggest the need to re-evaluate challenges that confront trading programs.

Non-Point Source Ag Pollution in the United States

According to the 2000 National Water Quality Inventory, agricultural NPS pollution is the leading source of impairment to rivers and lakes, and a major contributor to degradation of estuaries (Figure 1). Pollutants from agricultural croplands and livestock operations include excess fertilizer, herbicides and insecticides, sediment, and bacteria.

Controlling agricultural runoff is a longstanding and difficult problem. Agricultural NPS pollution loading is spread over large areas, and monitoring and measuring it is technically difficult and expensive. Agricultural runoff is highly variable due to the effects of weather variability, site-specific characteristics of the natural environment (e.g., soil type and land slope), and non-observable farm management practices (such as timing and precision of fertilizer application). While the cumulative effect of agricultural runoff can be observed through ambient water qual-

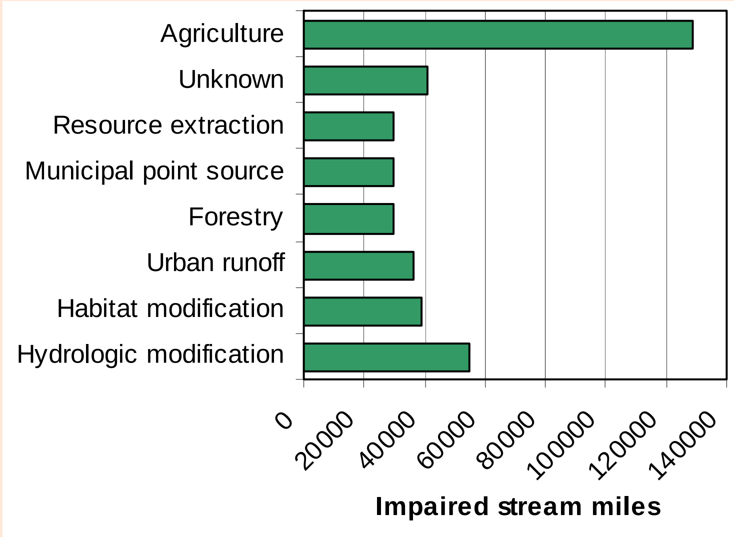

Figure 1. Leading sources of impairment of surveyed rivers and streams in the United States.
Source: USEPA, National Water Quality Inventory: 2000 Report, No. 841R02001, August 2002.

ity monitoring, it is generally impossible to trace the pollution back to specific farms. Existing computer models provide imperfect estimates of agricultural pollution loads. As a result, actual pollution amounts from a specific field or property are not fully known to regulators or farmers. Moreover, due to the variability in pollution loading, producers only partially control the runoff from their fields (Horan & Shortle, 2001; Braden & Segerson, 1993).

Accordingly, policymakers have long avoided environmental regulatory requirements for the agricultural sector. For example, the federal Clean Water Act excludes all agricultural sources (except for concentrated animal feeding operations - CAFOs) from federal regulation. Also, imposing environmental regulation will likely reduce agricultural producers' profits and may make U.S. agriculture less competitive than other nations with rules that are less stringent (Abdalla & Lawton, 2006). Instead of imposing environmental regulation, policymakers have offered incentive payment programs to encourage farmers to voluntarily adopt environmental protection measures in the form of best management practices (BMPs) (NRCS, 2006).

This approach has failed to solve the water quality problems caused by agricultural runoff. Limited federal and state budgets constrain expansion of incentive payment programs for agricultural BMP implementation, and the existing programs have not always been cost-efficient (Babcock et al., 1995). At the same time, the policy of further reductions of point source (PS) pollution loads is no longer feasible. Increases in urban population bring about increases in pollution loading from municipal PS (wastewater treatment plants), and the necessary upgrades of industrial and municipal PS are costly.

Water quality credit trading policy seems to offer an easy solution to these problems. Economists have long argued that allowing PS to purchase pollution reduction credits from NPS will provide a low-cost alternative to PS upgrades (Baumol & Oates, 1988; Pearce & Turner, 1990; Faeth, 2000). Trading programs provide PS with flexibility in how to achieve their pollution loading limits, which creates incentives to discover cheaper and more efficient abatement methods. Credit sales could provide farmers with needed financial resources for BMP implementation. Trading is also attractive to policymakers and some stakeholders because it may provide private funds to supplement (or replace) federal and state incentive programs (King & Kuch, 2003).

However, agricultural pollution runoff does not meet the economic textbook definition of a tradable commodity. As a result, designing a water quality credit trading program poses a set of challenges. These are discussed in the next section.

Realizing the Potential: What Does Economic Theory Suggest as Critical Elements of a Water Quality Trading Program?

A water quality credit trading program is established to meet specific pollution reduction goals. Table 1 summarizes elements that are necessary for inclusion or consideration in the implementation of a program.

Critical elements of a water quality trading program. Even with these components in place, certain challenges must be addressed for a water quality credit trading program to operate. Many of the challenges relate to PS-NPS trades, where the regulated community (NPDES[1] permit holders) meets the unregulated community (agriculture and other NPS). In a 2005 issue of Choices, King examined the potential supply and demand for water quality credits. King states that, on

1. *National Pollutant Discharge and Elimination System.*

Table 1. Critical elements of a water quality trading program.

Public water quality goals	Set by federal, state, or local authorities based on public input and can be defined in terms of ecosystem function, fish population or public safety, or as surface water quality standards.
Pollution cap for a watershed	Limit on the total pollutant load from all sources to a water body. The justification for and size of the cap is based on the public's water quality goals. Usually the cap is set for an annual load of specific pollutants.
Regulated baseline for point sources or nonpoint sources	Numeric level of pollutant load allowed at a particular point in time. If all polluters meet their regulated baseline, the pollutant cap for the watershed will be obtained.
Unregulated baseline for agricultural nonpoint sources	Minimum level of pollution abatement that an unregulated agricultural operation must achieve before it can participate in a trading program. Sometimes called the threshold.
Credits	Units of goods (pollution reduction) to be traded in the water quality credit market. Credits are generated for every unit of pollution reduction beyond the baseline level.
Sellers (credit suppliers)	Dischargers that reduce pollution below the baseline and generate credits for sale in the market. Credits can also be sold by intermediaries, if allowed by program rules.
Buyers (demanders for credits)	Dischargers with regulated baselines for whom pollution reduction is expensive. For these sources, it is less costly to buy pollution credits from other parties and use these credits to help achieve their baseline loads. Credits can also be purchased by intermediaries and third parties, if allowed by program rules.
Trading ratio	Number of load reduction credits from one source that can be used to compensate excessive loads from another source.
Regulator	Entity that determines the water quality goals, establishes caps for pollutants in a watershed, approves and administers the trading program, and monitors and enforces the rules.

the demand side (PS), few dischargers are interested in buying water quality credits if the discharge restrictions are weak or un-enforced. More recently, many states have set limits for PS that are either already binding or are expected to become binding as populations grow. In some states, sources will be required to completely offset all new pollution loads. Thus, we expect that the demand for credits will change. In relation to NPS, King associates the lack of supply with agricultural producers' desires to avoid environmental regulation. King argues that by participating in trading programs, producers make the implicit admission that NPS pollution can be measured and controlled. As a result, some farmers are concerned that trading could lead to increased regulation. However, in the past few years, a shift in perspective has been occurring. The federal and many state governments have passed regulations that require agricultural producers to implement practices to better manage runoff from their farms. Thus, producers are beginning to view trading as a way to hold off the implementation of future regulations. Despite these changes in conditions affecting both the supply and demand of potential water quality credit trading markets, other significant challenges still confront trading programs. Some of the key challenges are discussed below.

Challenges to Water Quality Credit Trading

Setting pollution caps. In order to ensure that a water quality credit trading program achieves public water quality goals, a maximum loading or "cap" for each pollutant must be set for a watershed and enforced by the regulatory agency. While public water quality goals are often linked to services a water body provides (e.g. fish habitat), trading requires that a cap be defined for specific pollutants. This presents a challenge for accurately estimating the amount of pollution reduction necessary to achieve the public goals. In addition, many trading programs leave unregulated agricultural NPS out of the pollution cap, eliminating the link between public water quality goals and the program results (King & Kuch, 2003). Moreover, consistent enforcement of the cap is a necessary condition for trading.

Establishing allowable pollution limits (baselines). An unrestrictive cap on PS can diminish or eliminate the demand for credits. Conversely, setting a high baseline can reduce the NPS will or ability to produce an adequate supply of credits. Besides affecting the functionality of the credit market, assigning baselines raises the fairness issue since the parties with restrictive limits need to incur costs to achieve these limits. Baseline limits also raise questions about responsibility for pollution clean-up and about property rights of landowners. For example, many agricultural BMPs are funded with public cost-share money. A debate exists about whether BMPs installed with public funds are the property of farmers, and if so, whether these credits should be eligible for trades (Horan et al., 2004).

Theoretically, the agricultural baseline load should be linked to public water quality goals. This guarantees that the reductions beyond the baseline ("credits") reflect additional environmental benefits produced by the source and supplied to the water quality credit market. In practice, the baseline is often set in relation to the current level of pollution, without regard to public water quality goals. In addition to jeopardizing public water quality goals, such baselines may create perverse incentives. For example, baselines may penalize those who have already implemented BMPs and reward those who have not by paying them for BMP implementation through credit sales (King & Kuch, 2003).

Complexities in establishing credits and associated risks with agricultural credits. For NPS, pollution reduction from a BMP is difficult to accurately predict and monitor. The effectiveness of a BMP depends on its age, implementation factors, how well it has been maintained, and on site-specific conditions. Scientific models are often used to estimate load reductions from BMPs. However, imperfections persist in models and estimated reductions from a BMP likely differ from actual loadings. This complicates the process of credit verification and creates uncertainty about the magnitude of water quality improvements from a trade (Ribaudo et al., 1999). Also, requirements to improve credit verification processes and increase accuracy in pollution reduction estimation can significantly increase costs associated with credit trading. Consequently, the number of willing credit sellers and buyers may be reduced (King & Kuch, 2003).

In addition to these measurement and verification complexities, the uncertain nature of agricultural pollution reduction also implies that credit sellers (farmers) do not have complete control over the "goods" they sell (Shortle, 2007), while credit buyers "face the risk of having the quantity bought falling below claimed level" (McCarl, 2006). In the majority of trading programs, variability in NPS pollution reduction is averaged and annual averages are used. The risks associated with agricultural credits are addressed in existing programs by requiring PS to purchase several NPS pollution reduction units to compensate for one unit of their own pollution increase (i.e., uncertainty trading ratio). However, such trading ratios implicitly increase the price the PS needs to pay for NPS pollution reductions. While the majority of trading programs employ ratios of greater than one, it has also been argued that trading ratios can be either less than or greater than one, depending on the variability of the agricultural discharges (Horan, 2001; Horan et al., 1999; Horan & Shortle, 2001).

Transaction costs. Transaction costs are costs that must be incurred to carry out a trade. Examples include the degree of difficulty in finding a buyer or seller, verifying credits, and negotiating and enforcing a trade. Trading will not occur if the transaction costs exceed the benefits of a potential trade (Stavins, 1995; Malik, 1992; Krutilla, 1999). Water quality credit trading programs that involve agricultural NPS are characterized by higher transaction costs than programs involving PS only. The transaction costs of finding a trading partner are higher because NPS are widely distributed across a watershed, and each source can generate only small numbers of credits in comparison with the larger demand of PS credit buyers (Woodward, 2006).

In addition to the costs of finding a trading partner, the measurement, verification, and enforcement of agricultural NPS pollution reduction can be costly because of the nature of NPS pollution runoff (Woodward, 2006). Also, for all water quality credit trading programs, negotiating a trade can be difficult because of the novelty of the markets (Woodward, 2003). Unlike other environmental markets (e.g., wetland banking or SO_2 emissions trading programs), rules for water quality credit trading are not yet clearly defined and vary across programs. Many programs are complex, which increases the transaction costs for reaching agreements between potential credit trading partners. Examples of unclear and complicated rules include the credit certification process, credit resale, credit life span, monitoring and maintenance, liability, sale approval prices, and pricing. For example, in their survey of farmers and agency staff to assess perceptions of policies for NPS control, McCann and Easter (1999) found transaction costs for water quality credit trading to be problematic. The survey revealed that the trading program's administrative costs were perceived to be the fifth most expensive among the policies considered. Woodward (2003) suggested that transaction costs associated with NPS trades may decrease as program participants become more familiar with the rules and other trading partners, and become more confident in credit estimation and approval procedures.

Enforcing contracts and liability issues. For the benefits of trading to be realized, there must be a mechanism to ensure that agreements arrived at are met. For example, in a PS-NPS trade, the potential buyers (PS) are liable for achieving pollution reductions as mandated by their NPDES permit limits. In contrast, the only document binding the potential sellers (NPS) is the private contract with the buyer. Most

The genesis of water quality credit trading in the Chesapeake Bay Region. Years of nutrient and sediment related pollution have caused significant impairments in the Chesapeake Bay. In 2000, the renewed Chesapeake Bay Agreement established ambitious targets for member states to significantly reduce their portion of nutrient pollution by 2010. These regional goals have had a ripple effect on each state in the watershed.

By 2003, Maryland instituted tributary strategies that placed caps on nutrients entering the state's waters. These caps were the impetus for Pennsylvania to seek new means for reducing its nutrient loads that flow across state lines. In 2006, Pennsylvania adopted its nutrient trading policy that enables PS-NPS trades. Pennsylvania is also attempting to ratchet down municipal sewage treatment plants' nutrient limits.

Virginia recently established a PS-PS trading program with the intent to eventually include NPS in trades.

Maryland and West Virginia are also in varying stages of developing state trading programs.

It is much too soon to judge how successful water quality credit trading will be in meeting the collective reductions necessary for improving and restoring the Chesapeake Bay.

existing trading programs hold the buyer responsible for monitoring the seller and enforcing the trade agreement. However, because the credit buyer and seller are more likely to focus on the credit price (as opposed to credit quality, i.e., delivering actual pollution load reductions), the regulator may bear more responsibility for verifying credits, and enforcing agreements (King & Kuch, 2003). By holding only the credit buyer liable for achieving pollution reductions, the regulator reduces the buyer's (PS) willingness to engage in an agreement. Suggested approaches to alleviate liability issues include the use of a mediator that can monitor and enforce the trading contract and place purchased credits in an "insurance pool" to guarantee that the NPDES limits are met even if one of the sellers fails to deliver the credits. The latter approach is used by the Pennsylvania and Ohio programs.

Leakage. Implementation of a trading program in one watershed or region can potentially lead to countervailing actions in areas outside the watershed. Stephenson et al. (2005) define leakage as an occurrence in which "a trade results in a net increase in loads." For example, it is proposed that some of the agricultural credits certified by Pennsylvania's trading program be generated by transporting manure/poultry litter to nutrient-deficient regions outside of the Chesapeake Bay watershed in Pennsylvania. If information concerning nutrient availability in soils in the receiving watershed is not well known, manure/litter importation can lead to increases in water pollution. Stephenson also provided an example about a farmer who installs a riparian buffer as a BMP, and generates and sells credits. However, to compensate for reductions in productive land due to buffer implementation, the farmer expands the productive acreage in a different place, increasing the nutrient and sediment loads in that vicinity.

Scale of the trading program. Many existing water quality credit trading programs have been developed for relatively small watersheds. However, in a larger watershed, more opportunities exist to find a trading partner with significantly different pollution abatement costs. Thus, greater reductions in costs of meeting public water quality goals can be realized. Also, in a large watershed, a large number of buyers and sellers can help ensure that the market participants do not exploit the market power or distort efficient trading (Woodward, 2003; Hahn, 1989: King & Kuch, 2003). Currently, the regulatory driver for developing trading programs for larger regions is often lacking. Water quality standards or Total Maximum Daily Loads (TMDLs), which are considered a driving force for trading programs, are usually set for small watersheds. The Chesapeake Bay Region is an exception.

Sizing up the Evidence

A variety of trading and other market-like programs have been created over the past 20 years. Failure to address the challenges identified above is a reason why many of these programs have been short-lived or have not resulted in much trading activity (Breetz et al., 2004). There are also examples of successful water quality credit trading programs. The Long Island Sound (CT) and Tar-Pamlico Basin (NC) trading programs both experienced relatively long lives and resulted in documented pollution load and cost reductions. The programs resulted in reallocations of pollution caps among PS and did not address the challenges posed by NPS runoff.

Alternatively, trading programs in the Miami Watershed (Ohio), South Nation River Basin (Ontario, Canada), Cherry Creek (Colorado), Beet Sugar Cooperative and Rahr Malting Pollutant Offsets (Minnesota), and Red Cedar River (Wisconsin) all involve both PS and agricultural NPS (Breetz et al., 2004). Some of the challenges associated with agricultural runoff have been addressed in these programs by creating an intermediary between credit sellers (NPS) and credit buyers (PS). Such intermediaries (referred to as aggregators, credit banks, or brokers) can reduce the transaction costs of finding trading partners, and credit verification and monitoring. Intermediaries may also potentially bear some liability for delivering pollution reductions specified in trading agreements. In existing programs, such intermediaries are a joint venture of the regulatory authorities and public and private entities. The funds used to purchase credits from agricultural NPS have been drawn from both PS and federal- and state programs. In other words, the programs are essentially hybrids between market-based trading programs and government-managed tax-and-subsidy schemes. The rules for selecting NPS projects to generate credits and for selecting prices that PS must pay differ among the programs, making some of them more like market-based trading and others more like government-directed offsets (Stephenson et al., 2005).

Conclusions

Unresolved Public Policy Questions

Water quality credit trading has been perceived by many as an alternative to command and control regulations. Yet, water quality regulation is a necessary driver for trades to occur. Thus, trading alone cannot solve the challenges posed by largely uncontrolled agricultural pollution. A number of important public policy questions have been raised as discussions of trading have occurred. For the most part these questions remain unanswered or various interest groups and governmental agencies have answered them differently. Among the questions are:

Do the political will and resources exist? Do federal and state decision-makers have the political will and resources to enforce regulatory caps on PS and NPS? This is a critical step because the value of a water quality credit is dependent on the enforcement of this cap. Without an enforced cap, there is nothing of value for potential market participants to trade (King & Kuch, 2003).

Will government define the right to pollute and the right to clean water? This question focuses on a key underlying issue in trading program design. In terms of trading, "you can't sell what you don't own". The answer to this question determines who pays and who benefits from trading. As noted, an example of the unresolved nature of this question is the debate over farmers' ownership rights to publicly funded BMPs. Opinions vary over assignment of property rights to private parties from publicly funded projects, raising questions about the water quality benefits from such "double-dipping." Allocating and enforcing property rights is a fundamental role of government. Are governments willing to reconcile property rights questions of this nature?

Will trading programs be accepted as equitable? Is it fair when one category of polluters – PS – have regulatory effluent limits placed on them while NPS are required to meet only program-specific baseline requirements? King and Kuch (2003) suggest that PS dischargers believe that there is an inequitable allocation of pollution rights to NPS dischargers.

Will market approaches for environmental goods or services be accepted? Some stakeholder groups oppose trading because they believe that it is inappropriate to put a price on natural and environmental resources and trade them in a market (Goodin, 1994; Hahn, 1989; Hahn & Hester, 1989; King & Kuch, 2003; Woodward, 2003). Some are suspect of market-based approaches and perceive trading as excluding environmental interests. Also, the terminology associated with water quality credit trading is not well understood by environmental, farming, and development communities. This may prevent them from effective participation in trading program development.

Where to from Here?

Recently, federal and state policymakers as well as some stakeholder groups have promoted market-based approaches to address the agricultural water pollution. We described some of these policy activities and raise the question: what can be expected from market-based programs, and specifically trading, in addressing the long-standing and difficult issue of water pollution from agriculture?

After assessing these challenges, we conclude that federal and state policymakers are expecting too much from trading as a tool to address NPS water pollution from agriculture. Since King's 2005, *Choices* article, institutions have made progress creating a more supportive trading environment. Nevertheless, the physical and regulatory context for agricultural NPS pollution does not match the conditions that economic theory suggests are needed for widespread trading to occur. The majority of agricultural sources do not face an enforceable cap. Thus, it is difficult to ascertain whether PS-NPS trades will create new water quality improvements. King and Kuch (2003) state that PS-NPS trades cannot achieve water quality standards in watersheds where the NPS dischargers are responsible for the bulk of nutrient discharges or where very large reductions in nutrient loading are necessary. The lack of documented success in water quality credit trading adds credence to the idea that there is a mismatch of theory and practice.

We believe that water quality trading in agriculture should continue to be explored and be field-verified for its use as a tool to reduce the costs associated with pollution reductions. However, in the interim, policymakers must reduce their expectations and reliance on market-based solutions until there is more evidence that validates that these programs can help meet pollution reduction goals. Policymakers must recognize that water quality credit trading in agriculture is still in its infancy and that the challenges identified are not yet well understood.

Ongoing trading efforts should be regarded as experiments. Increased attention must be paid to designing future experiments to better understand the physical, social, economic, legal, and policy considerations. This will require greater exchange among economists, physical scientists, policymakers, farmers, municipalities, community members, and other stakeholders. As a more thorough knowledge of trading as a tool to address agricultural water quality problems is gained, its potential for use to help meet public water quality goals increases.

For More Information

Abdalla, C.W., & Lawton, J.L. (2006). Environmental issues in animal agriculture. *Choices* 3rd Quarter, *21*, (3). Available online: http://www.choicesmagazine.org.

Babcock, B.A., Lakshminarayan, P.G., & Wu, J. (February 1995). Renewing CRP: Results from a study of alternative targeting criteria. CARD Briefing Paper 95-BP 6, Center for Agricultural and Rural Development, Iowa State University.

Baumol, W.J., & Oates, W.E. (1988). *The Theory of Environmental Practice.* Cambridge: Cambridge University Press, 2nd ed.

Braden, J.B., & Segerson, K. (1993). Information problems in the design of NPS Pollution Policy. In C.S. Russell and J.F. Shogren (eds.), *Theory Modeling and Experience in the Management of NPS Pollution*. Boston: Kluwer Academic Publishers.

Breetz, H.L., Fisher-Vanden, K., Garzon, L., Jacobs, H., Kroetz, K., & Terry, R. (2004). Water quality trading and offset initiatives in the U.S.: A comprehensive survey. A report for the U.S. Environmental Protection Agency. Hanover, NH: Dartmouth College Rockefeller Center. Available online: http://www.dartmouth.edu/~kfv/waterqualitytradingdatabase.pdf (Accessed February 26, 2007).

Environmental Trading Network (ETN). (2007). Water Quality Trading – State Programs and Rules. Available online: http://www.envtn.org/wqt/stateprograms_page.html#usprograms (Accessed February 26, 2007).

Faeth, P. (2000). Fertile ground: Nutrient trading's potential to cost effectively improve water quality. Report by World Resources Institute, Washington, DC.

Goodin, R.E. (1994). Selling environmental indulgences. *Kyklos, 47*, 573-96.

Hahn R.W. (1989). Economic prescriptions for environmental problems: How the patient followed the doctor's orders. *Journal of Economic Perspectives, 3*(2), 95-114.

Hahn R.W., & Hester, G.L. (1989). Marketable permits: Lessons for theory and practice. *Ecology Law Quarterly, 16,* 361–406.

Horan, R.D. (2001). Differences in social and public risk perceptions and conflicting impacts on point/nonpoint trading ratios. *American Journal of Agricultural Economics, 83*(4), 934–41. doi:10.1111/0002-9092.00220.

Horan, R.D., Shortle, J.S., & Abler, D.G. (April 2004). The coordination and design of point-nonpoint trading programs and agri-environmental policies. *Agricultural and Resource Economics Review, 33*(1), 61-78.

Horan, R., Shortle, J., Abler, D., Ribaudo, M. (1999). Second-best markets for point/nonpoint pollution trading. Paper presented at the European Association of Environmental and Resource Economists annual meeting, Oslo, Norway.

Horan R.D., & Shortle, J.S. (2001). Environmental instruments for agriculture. In Shortle, J.S. and D.G. Abler (eds.), 224 pp. *Environmental Policies for*

Agricultural Pollution Control, New York: CABI Publishing.
King, D.M. (2005). Crunch time for water quality trading. *Choices, 20*(1), 71-75.
King, D.M., & Kuch, P.J. (2003). Will nutrient credit trading ever work? An assessment of supply and demand problems and institutional obstacles. *Environmental Law Reporter News and Analysis, 33*(5), 10352-19368.
Krutilla, K. (1999). Environmental policy and transactions costs. In J.C.J.M. van den Bergh (ed.), pp. 249-64, *Handbook of Environmental and Resource Economics*. Glos, UK: Edward Edgar Publishing Limited.
Malik, A.S. (1992). Enforcement costs and the choice of policy instruments for controlling pollution. *Economic Inquiry, 30*, 714-21.
McCann, L.M., & Easter, K.W. (1999). Differences between farmer and agency attitudes regarding policies to reduce phosphorus pollution in the Minnesota River Basin. *Review of Agricultural Economics, 12*, 189-207.
McCarl, B. (March 2006). Measurement and quantity uncertainty. Presentation at a Workshop on Environmental Credits Generated Through Land-Use Changes: Challenges and Approaches, March 8-9, 2006. Baltimore, Maryland. Available online: http://www.envtn.org/LBcreditsworkshop/Uncertainty_Intro.pdf (Accessed February 27, 2007).
Natural Resources Conservation Service (NRCS) (2006). NRCS Conservation Programs. Available online: http://www.nrcs.usda.gov/PROGRAMS/ (Accessed April 26, 2007).
Pearce, D.W., & Turner, R.K. (1990). *Economics of Natural Resources and the Environment*. Baltimore, MD: Johns Hopkins University Press.
Ribaudo, M.O., Horan, R.D., & Smith, M.E. (1999). Economics of water quality protection from nonpoint sources. Washington, DC: USDA ERS Ag. Econ. Rep No. 782.
Shortle, J.S. (January 2007). Research opportunities and challenges. Presentation at Water Quality Credit Trading Symposium, USDA CSREES National Water Conference, January 29, 2007, Savannah, Georgia. Available online: http://www.mawaterquality.org/themes/trading_symposium_savannah.htm (Accessed February 27, 2007).
Stavins, R.N. (1995). Transaction costs and tradeable permits. *Journal of Environmental Economics and Management, 29*, 133-48.
Stavins, R.N., & Whitehead, B.W. (November 1996). The next generation of market-based environmental policies. Discussion Paper 97-10, RFF, 48 pp. Available online: http://rff.org/rff/Documents/RFF-DP-97-10.pdf.
Stephenson, K., Shabman, L., & Boyd, J. (2005). Taxonomy of trading programs: Concepts and applications to TMDLs, In Tamim Younos (ed.), pp. 253-285, *TMDLs: Approaches and challenges*. Tulsa, OK: Penn Press.
U.S. Department of Agriculture (USDA) Natural Resources Conservation Service. (January 2007). Agricultural Secretary Mike Johanns' remarks to the American Water Resources Association Meeting, January 23, 2007, Arlington, VA. Available online: http://www.usda.gov/wps/portal/!ut/p/_s.7_0_A/7_0_1RD?printable=true&contentidonly=true&contentid=2007/01/0011.xml.
U.S. Environmental Protection Agency (USEPA). (August 2002). National Water Quality Inventory: 2000 Report, No. 841R02001.
Woodward, R.T. (March 2006). The challenge of transaction costs. Presentation at a Workshop on Environmental Credits Generated Through Land-Use Changes: Challenges and Approaches, March 8-9, 2006. Baltimore, Maryland. Available online: http://www.envtn.org/LBcreditsworkshop/Transaction_Costs_Intro.pdf (Accessed February 27, 2007).
Woodward, R.T. (2003). Lessons about effluent trading from a single trade. *Review of Agricultural Economics, 25*(1), 235–45.

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