WATER QUALITY TRADING IN THE LONG ISLAND SOUND STUDY AREA: A PRELIMINARY LOOK AT SOME ECONOMIC ISSUES

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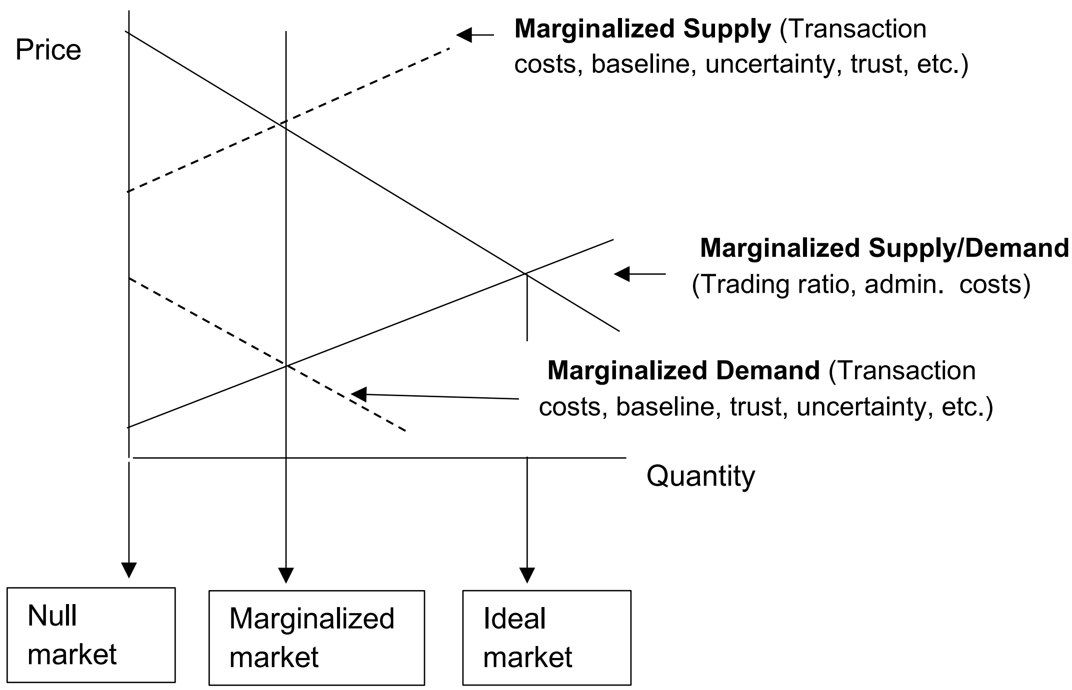
1. Introduction: Water Quality Trading and "Policy Utopias"

While markets for environmental goods have been around for a long time (for example, sulfur dioxide trading and carbon markets), markets for water quality trading have been slow to develop. A rather astounding amount of effort - spanning decades and entire academic careers - has been devoted to determining why water quality trading markets are not as robust as their air emissions counterparts.

Unlike a typical commodity, economists and policy makers must *create* a market for pollution trading. That creation requires policy choices to be made, the determination of which can drive further "wedges" between supply and demand. These policy choices include *trading ratios* (section 2), which may be decided in response to *risk and uncertainty* (section 3); *baseline determination* (section 4), which may limit eligibility to engage in the market, but may also determine the degree to which reductions are *additional* (section 5); *market structure* (section 6); and other institutional factors such as *credit banking* (section 7) and *credit stacking* (section 8). *Transactions costs*, while not a direct policy choice, are nonetheless an essential determining factor of the success or failure of a program, and include monitoring and enforcement costs as well as administrative costs (section 9). Finally, as markets are part of, not apart from, society, social considerations include *trust, norms, and communication* (section 10); and *distributional issues*, such as environmental justice and the possibility of hot spots (section 11).

Figure 1 shows a conceptual model of a nutrient trading market, as illustrated in Hoag et al. (Hoag et al., 2017). The ideal market price and quantity supplied are found where the downward-sloping solid demand curve intersects with the upward-sloping solid supply curve. Anything that increases a supplier's costs will tend to shift the supply curve up and to the left (the dashed supply curve), while anything that increases the cost to the buyer will shift the demand curve down and to the left (the dashed demand curve). If costs increase enough so that the demand and supply curves do not intersect, there will be no market.

Figure 1: Conceptual Supply and Demand Model for Nutrient Trading Credits, with Marginalizing Effects



Source: Adapted from Hoag et al., 2017.

Hoag et al. (Hoag et al., 2017) identified three environments required for a viable trading market:

> (1) an amenable *physical environment* with a commodity to trade, sufficient physical supplies, and sufficient physical demand; (2) an amenable *economic environment* with willing buyers and sellers, familiarity with the commodity and its controls, and a viable market infrastructure; and (3) a friendly *institutional environment* with willing policy makers/agencies with the necessary expertise, flexible regulations, and sufficient institutional commitment (Hoag et al., 2017).

A strong physical environment, Hoag et al. find, is most likely to be found where water quality is a concern and where both point and nonpoint sources can be found in abundance within the same watershed. They estimate the potential supply and demand by investigating the number of watersheds across the contiguous United States that do not meet their designated water quality standards, and by determining annual total nitrogen and total phosphorus loads from both point and nonpoint sources. Their results imply that only about 5 percent of impaired watersheds have feasible supply and demand conditions for nitrogen trading, and about 13 percent of watersheds are in the "Goldilocks zone" for phosphorus trading (Hoag et al., 2017).

Where the Long Island Sound Study Area falls on the spectrum between a "null market" and an "ideal market" rests in part on the characteristics of the study area, as well as the rules that policy makers establish. The remainder of this report investigates these policy choices, whereas the characteristics of the study area will be considered in a later report. Recommendations are based on a review of the academic literature and are to be considered preliminary. Recommendations specific to the Long Island Sound Study Area will follow after an inventory of the area is complete, as well as discussions with individuals associated with successful point-nonpoint trading programs.

2. Trading Ratios

One of the biggest policy decisions in designing a water quality trading program is choosing a trading ratio. Because pollution abatement from nonpoint sources is by its nature stochastic and measurement is difficult, some ratio of point to nonpoint sources is necessary. A healthy if somewhat esoteric debate has arisen among economists as to the appropriate trading ratio. In most actual cases the trading ratio is above one - in other words, to avoid reducing its load by one unit, a point source would be required to purchase more than one unit from a nonpoint source (Malik et al., 1993). Such a trading ratio may be optimal under certain (political) circumstances. However, from an economic perspective, Horan and Shortle (Horan & Shortle, 2005) argue that a trading ratio of less than one might be more appropriate under certain circumstances. They point to two different sources of uncertainty (see section 3): uncertainty due to stochastic nonpoint loadings and uncertainty about the effectiveness of nonpoint source pollution controls. They argue that a low trading ratio (making it less expensive for the point source to buy reductions from the nonpoint source) is "socially beneficial because it leads to a reduction in variability of loadings that could not have been achieved if the abatement were conducted by the point source alone" (Horan & Shortle, 2005). However, a high trading ratio may be called for because of the uncertainty in the effectiveness of nonpoint controls.

Furthermore, the "correct" trading ratio should, theoretically, reflect the ratio of the marginal enforcement costs between point and nonpoint source: "An increase in the marginal enforcement costs for the nonpoint source [should] raise the optimal trading ratio, shifting abatement towards the now relatively less expensive point source (Malik et al., 1993). However, in reality, trading ratios do not vary once established.

An interesting question arises regarding "which risk" the trading ratios are meant to address. Horan points out that a regulator may select a trading ratio that is larger than economically efficient because of its desire to reduce political risk (that is, the risk associated with uncertain pollution controls) as opposed to socially perceived risk (the risk associated with uncertain environmental impacts). If that is the case, he continues, there are two probable repercussions:

> First, environmental risk will be inefficiently managed, leading to larger expected damages at the margin. Second, a larger trading ratio means that point sources will have fewer incentives to take advantage of cost savings that may come from trading with nonpoint sources. Thus, the result of the political–economic model may be larger expected damages and larger control costs than what is economically optimal.

One interesting proposal is to set trading ratios based on attenuation rates (Keller et al., 2014). Attenuation is the fraction of nutrient input removed per kilometer of stream reach. It is a function of several variables, including flow rates, slope, river channel depth, and land use (e.g., forested versus urban versus agriculture). Keller et al. develop a formula by which a trading ratio could be developed:

$CRPoU = (F_{farm\text{-}to\text{-}river} \times F_{in\text{-}stream} \times F_{equivalence} \times F_{safety})LR$

where:

CRPoU = credit at point of use (PoU);

$F_{farm\text{-}to\text{-}river}$ = attenuation from point of credit generation (e.g., farm, stormwater BMP, point source) to edge of river;

$F_{in\text{-}stream}$ = in-stream attenuation from entry point to PoU;

$F_{equivalence}$ = accounts for load reduction in different N or P species than needed at the point of use;

F_{safety} = safety margin for uncertainties in attenuation calculation;

and LR = load reduction at the point of credit generation (Keller et al., 2014).

They recommend that, since attenuation coefficients vary according to local conditions, each watershed should be modeled to develop watershed-specific parameters. Using Monte Carlo simulations, the probability distribution of the attenuation coefficients can be developed, and an adequate safety margin selected. Moreover, they believe that trading ratios should be developed considering the location of the buyer and the seller within a watershed, with the safety margin increasing as a function of distance (Keller et al., 2014).

Ghosh and Shortle (2009) likewise recommend against a “one size fits all” trading ratio, instead relying on a “new definition of a pollution credit as a multi-attribute good” (G. S. Ghosh & Shortle, 2009)). The reasons for this are three-fold: 1. Trading ratios should be “optimally differentiated across sources to address differences in relative risk;” 2. Optimal trading ratios between point and nonpoint sources may indeed be less than one, “reflecting the fact that nonpoint sources are often a greater source of risk than point sources;” and 3. Optimal trading ratios “depend on the choices of other market design parameters, including the allocation of initial allowances and the cap placed on the aggregate supply of permits, and thus optimality requires selecting these parameters simultaneously" (G. S. Ghosh & Shortle, 2009). They propose that the commodity to be traded should be a function of the mean and the standard deviation of all emissions sources in the watershed. Rather than the environmental agency having to determine the trading ratio (and risk either under- or over-estimating), the environmental agency would only need to provide the underlying distribution of emissions in the watershed.

The 2019 memo updating the 2003 Water Quality Trading Policy recommends the "use of appropriate models and verification practices [that] may eliminate the need for trade ratios which ultimately reduce the value of a water quality credit and increase the cost of participation" (Ross, 2019).

3. Risk and Uncertainty

Walker and Selman (Walker & Selman, 2014) have characterized several different types of uncertainty: biophysical uncertainty, in which the relationship between pollution reduction efforts and actual pollution reduction is not clear; extreme event uncertainty, where events such as extreme rainfall or drought, or even earthquakes or fires, could cause best management practices (BMPs) to fail; behavioral uncertainty, in which point sources, who maintain legal liability for meeting their permit, may be uneasy about entering into an agreement with a nonpoint source due to the uncertainty in their pollution reductions; regulatory uncertainty, in which the potential for shifting policies in the future may inhibit trading; and finally market uncertainty, in which uncertainty about the adequacy of supply and demand could generate reluctance to enter a market.

This document has already discussed biophysical uncertainty elsewhere. However, the other types of uncertainty that Walker and Selman address have not received as much attention in the literature. They propose reducing these different types of risk and uncertainty by creating or strengthening regulatory or financial institutions that can act as hedges against possible failure. The table below is adopted from Walker and Selman.

Table 1: Possible Institutions to Address Risk and Uncertainty

Type of risk or uncertainty	Possible solutions
Biophysical and scientific uncertainty	Improved scientific understanding; direct measurement of the effects of BMPs both before and after installation; development of tools and models to estimate BMP effectiveness (especially in markets with a large volume of trades); establishment of trading ratios.
Extreme event uncertainty	Establishment of credit reserves and/or insurance pools.
Behavioral uncertainty	Usage of aggregators, institutions that pull together credits from multiple sources and act as intermediaries between buyers and sellers; verification to confirm that a best management practice is installed and maintained to meet design specifications; establishing a system of shared financial liability.
Regulatory uncertainty	Guaranteeing that credits that already have been bought and sold will remain valid for the life of the permit, even if regulations change; establishment of agricultural certainty programs, guaranteeing that “pre-compliance credit generating activities” are sufficient for future regulations; policies promoting transparency and consistency.
Market uncertainty	Certification of credits before BMPs are installed; establishment of credit banks/clearinghouses; establishment of a government guarantee program that would agree to purchase credits that go unsold.

Source: Walker and Selman (2014)

In summary, Walker and Selman propose that a combination of enhanced and targeted monitoring, centralized credit banks and/or reserves, aggregators, insurance programs and “agricultural certainty” programs, as well as government guarantees for permits that go unsold can help to reduce risk and increase the probability that nonpoint sources will participate in the market. This analysis strongly implies that these institutions should be firmly in place before point-nonpoint trading begins (Walker & Selman, 2014).

4. Baseline Determination

Determining the baseline is one of the first questions to resolve before trading can begin. A baseline for trading is essentially the pollution control requirements that would apply to both buyers and sellers of credits in the absence of a pollution trading market. The baseline must be met before any pollution credits can be generated. Baselines come in three "flavors": date-based baselines, practice-based baselines, and performance-based baselines. Date-based baselines take a farmer's current practices as the baseline, and any BMP installed after that date would generate credits.[1] Practice-based baseline specify that certain practices be installed prior to trade, and that any improvements above and beyond those practices would generate credits. Performance-based baselines require that farmers reduce runoff by a certain amount in order to generate credits (American Farmland Trust, 2013).

Point sources are required to hit their baseline through three methods. The clearest is pollution prevention, reuse, or recycling so their discharge meets water quality-based effluent limitations (WQBELs). The second is to install treatment technology which would minimize the nutrient output of its effluent. The third is the trading platform where it can purchase the right to pollute more from nonpoint sources. If the source reduces its output below the baseline limit, it would also be eligible to generate credits for trade (US Environmental Protection Agency Office of Wastewater Management, 2009).

While baselines are the foundation of trading programs, their implementation determines the effectiveness and participation of its execution. Two reports looking at the effectiveness of trading programs in the Chesapeake Bay and Conestoga watersheds criticize the baseline

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[1] While other sources of nonpoint source pollution besides agriculture (for example, stormwater runoff) may be eligible for credit generation, the economic literature has focused primarily on agricultural sources.

requirements exceeding current management practices, finding that these “high” baselines can be a major barrier preventing nonpoint sources from entering the trading market. Baselines determine the cost of creating nonpoint source offsets as well as their supply, shifting the supply curve to the left. This also limits the equity of the program because there are fewer participants in the program who are able to access gains from trade (G. Ghosh et al., 2011).

The baseline can be preset by existing state regulations. However, most states have no enforceable regulations for management practices. This then creates a dilemma for the program: if baselines are at minimal management practices, the cost of offsets is low which may not entice low-management farmers to improve practices, yet those with better practices already gain from trade. The Conestoga study uses an economic and pollution model to compare the generation of offsets for a dairy farm through simulation. They found that, “[a] baseline that requires a minimum level of stewardship before market entry will benefit good stewards who have already adopted the requisite practices. Poor stewards are at a distinct competitive disadvantage because a major part of their investment in conservation measures (streambank BMPs) is ineligible to generate offsets. Unless offset prices are high they would not enter the market. At these high prices, all good stewards would already have benefited from trade” (G. Ghosh et al., 2011).

The Chesapeake Bay study was similarly focused but also introduced the idea of subsidizing farmers to reduce the cost of pollution abatement. Their study created two hypothetical trading programs for the entire region and investigated effects of different baseline choices on supply and demand curves. Results suggest that a program that sets the baseline at current practices provides the greatest benefits to point sources, as credits are cheap, but such a program does not reduce the load allocation of nonpoint sources. On the other hand, a program that requires the implementation of new BMPs before generating credits could reduce the incentive for nonpoint sources to trade, but there is the potential for increased point source abatement compared to a zero-improvement baseline. “The more farmers have to do in order to be eligible for trade, the less likely a farmer will find in profitable to enter a trading program,” thus reducing the amount of farmland that meets baseline, reducing credit supply and increasing credit prices and raising costs further for point sources (Ribaudo & Savage, 2014).

Ribaudo et al. also investigated the effect of a subsidy on the simulated market, reasoning that if a baseline reduces the supply of credits in the market, the government could subsidize certain practices necessary for nonpoint sources to meet the baseline. However, as in most cases practices subsidized by the government cannot generate credits (to avoid "double dipping), the supply constraints caused by the subsidy actually caused the hypothetical supply curve to shift to the left, "in this case, both taxpayers and point sources bear a cost from providing a subsidy" (Ribaudo et al., 2014).

Baselines are part of the fundamentals of Water Quality Trading programs, but they are challenging to design in a way that benefits all stakeholders. Determining where the baselines are set develops the expectations for how the program will operate and the amount of participation it garners. However, there is a balance that needs to be maintained between baseline stringency, market participation, and additionality. The 2019 memo updating the 2003 Water Quality Trading Policy recommends documenting current conditions as a "simple and appropriate baseline," as overly complicated baseline determinations are "often a barrier into a market-based program" (Ross, 2019).

5. Additionality

Duke et al. (Duke et al., 2014) define additionality as:

> the idea that an ecosystem service from a management practice—say one that sequesters carbon or reduces nutrient load—currently is not provided or would not have been provided in the absence of a new policy institution seeking to increase service provision. Nonadditionality, then, will be defined as an ecosystem service provided prior to the policy, but that is claimed to be an environmental improvement outcome of the policy. This is not of environmental quality concern if the nonadditional load is not used to create offsets.

However, if the non-additional load *is* used to create offsets, it is possible that a water quality trading program would generate “too many” permits, resulting in an actual reduction in water quality after the program is implemented.

Savage and Ribaudo identify four different mechanisms that could lead to the creation of non-additional credits in a trading program. One is intentional choice: the government agency may deliberately set the baseline in order to reward “good stewards” or early adopters. A second is continuing payments: the government may continue to pay for a program even after a contract expires, whereas the farmer would have continued that practice in the absence of the payment (perhaps because the practice is actually profitable). A third is that governments may pay for new practices that farmers would have adopted without the program. Finally, farmers may deliberately misrepresent their management choices, especially when monitoring costs are high (Ribaudo & Savage, 2014).

Non-additionality is most likely to arise when monitoring costs are high, where there is an incentive for farmers to destroy a structural BMP (or alter an annual BMP) in order to re-enroll in subsequent years, and where government payments create the potential for double dipping. The potential consequences of non-additionality are two-fold. One is, as stated, the possibility of too many credits being issued, and thus a decrease in water quality. The second is increased costs for the government agency, whereby they continue to pay farms for practices in which they would have engaged even without the water quality trading program. A third, alternative scenario could be the lessening of government support for conservation in the region (a phenomenon termed “reverse crowding out,” where the payment for a particular BMP crowds out government conservation payments) (Ribaudo & Savage, 2014).

The problem of non-additionality may be avoided through eligibility baselines, monitoring and inspection programs, and retirement rates for credits generated through practices partially supported by other government agencies.

6. Market Structures

There are four main types of market structures for WQT: exchanges, bilateral negotiations, clearinghouses, and sole-source offsets (Woodward & Kaiser, 2002). These market structures can be combined to create a more flexible system that can more easily adapt to different circumstances.

Exchanges

Greenhalgh and Selman (Greenhalgh & Selman, 2012) define exchange markets as "where buyers and sellers meet in a public forum...with all commodities being equivalent and all prices being observed." Exchanges are potentially the most cost-effective market structure, but they do not easily conform to the needs of WQT. Exchanges require a uniformity that is hard to achieve within WQT, as placement within a watershed could affect the value of pollution reduction. For example, reducing pollution upstream improves WQ for everyone downstream, making upstream improvements more valuable. Accounting for these differences diminishes uniformity of credits, making an exchange market difficult. CWA regulation, and the monitoring and reporting required for WQT, are another hurdle for uniformity. Exchanges are more suited to larger markets as smaller watersheds might not have enough traders to support an exchange market.

Bilateral Negotiations

Greenhalgh and Selman describe trades as "one-on-one negotiations where a price is typically arrived at through a process of bargaining and not simply by observing a market price" (Greenhalgh & Selman, 2012). While it is relatively inexpensive to establish a bilateral negotiations market, transaction costs are generally quite high due to information, contracting, and enforcement costs. Since this structure allows for a case-by-case assessment of trades, lack of uniformity can be accounted for to ensure that quality standards are met. Extremely stringent monitoring practices can lead to long lag times between review and approval of trades and thus discourage buyers and sellers from entering the market, so a balance between functionality and monitoring must be reached. Because of the flexibility inherent in bilateral negotiations markets, they are particularly well suited to WQT despite high transaction costs.

Water-Quality Clearinghouses

Greenhalgh and Selman describe a clearinghouse as "an intermediary in a trading program that aggregates credits from different sources with different prices and converts them to a fixed price commodity that is resold" (Greenhalgh & Selman, 2012). The clearinghouse takes on the responsibility of monitoring and reporting on credits and also takes on much of the risk associated with trading. Since buyers and sellers only interact with the clearinghouse, their transaction costs are reduced and buyers have the additional benefit of knowing that credits have already been approved by regulators. Clearinghouses do require a level of uniformity for the market to function, so, similar to exchanges, it will not work with all watersheds. Clearinghouses are typically handled by a government agency; however, in some cases the responsibility for management is delegated to a third party. Woodward and Kaiser list third party management as a type of clearinghouse market structure while Greenhalgh and Selman list it separately.

Third-Party Broker:

A third party broker is "an intermediary in a trading program that aggregates credits from different sources with different prices to either re-sell directly to a buyer or bundle credits together creating large credit lots for sale" (Greenhalgh & Selman, 2012). Generally, the third party operates independently from the program itself.

- The paper *Establishing a Clearinghouse to Reduce Impediments to Water Quality Trading* (O'Hara et al., 2012) describes the introduction of a clearinghouse market to the Chesapeake Bay WQT program and highlights some of the benefits gained from said introduction.

- The preexisting Bilateral Negotiations Market had generated few trades, with most of the regulated point sources opting to upgrade their facilities rather than engage with the market. Part of the reason for this avoidance was the high transaction costs involved with procuring credits and the risk of not being in compliance if a trade were to fall through.
- The Pennsylvania Interest Investment Authority was asked to take over the role of clearinghouse. Since they already had relationships with many of the groups that would be involved with trading, they were ideal for the position.
- Benefits included buyers being able to purchase a larger amount of credits than any one seller might have, knowing that the price of credits was minimized since they were procured through competitive auction, and transfer the risk and transaction costs.
- Bilateral negotiations are still open to those unable to procure enough credits through the clearinghouse, providing multiple ways of acquiring credits so as to ensure compliance (O'Hara et al., 2012).

Sole-Source Offsets

"Sources are allowed to increase nutrient discharge at one point if they reduce their nutrient discharge elsewhere" (Greenhalgh & Selman, 2012). Since sole-source offsets do not involve any actual trading, transaction and oversight costs are kept to a minimum. Sole-source offsets are a good option for those looking to reduce their net pollution load or in situations where achieving environmental standards cannot be addressed solely through point source and nonpoint source reductions. Unlike other market methods, sole-source offsets do not create incentives for polluters already in compliance with environmental standards to reduce pollution discharge.

From this analysis, bilateral and clearinghouses, alone or in tandem with other market structures, are the most frequently used market structures. More recent programs are more likely to adopt a clearinghouse, exchange, or third-party manager system, likely in order to reduce transaction costs and make the trading process more streamlined and simplified for participants. The case-by-case nature of bilateral negotiations can slow down the approval process if there is no standardized practice. That, in addition to the high transaction costs inherent in bilateral negotiations and the time it takes for buyers and sellers to find each other, deters participation (Nguyen et al., 2013).

7. Credit Banking

Credit banking is a structure of credit exchange where credits gained in one time period are saved or "banked" with the intent to offset discharge at a later period (Kieser, 2000). The justification of such a model is focused on the economic benefits instead of the ecological ones. It provides greater flexibility to point sources to meet compliance requirements to either sell credits at a later date or use them to temporarily increase their nutrient output (Willamette Partnership et al., 2015). The ability to sell credits later gives greater capital allocation for pollution control investments to promote a long-term focus. Banking could be a more efficient means of trade than bilateral exchanges because of greater flexibility (Kieser, 2000). One of the most attractive arguments for allowing banking, however, may be that federal and state subsidies are insufficient to fund nonpoint source reductions. If nonpoint sources are able to bank their credits, they may have more of an incentive to provide voluntary nutrient reductions.

The criticism of credit banking largely lies in a lack of ecological focus and legal risks. It provides permittees the option to use credits at a later date if they are not needed currently; however, doing so creates a risk of exceeding the TMDL as credits are not used in the same time period as they are generated. The Florida Department of Environmental Protection and the Idaho Department of Environmental Quality, for example, strictly ban the procedure (Willamette Partnership et al., 2015). The 2003 EPA Trading Policy stated that "[c]redits should be generated before or during the same period they are used to comply with a monthly, seasonal or annual limitation or requirement specified in an NPDES permit" (Environmental Protection Agency., 2003). However, the EPA's 2019 guidance memo does recommend the banking of offsets and water quality credits under certain circumstances, as their allowance "encourages early adoption of pollutant reduction practices, reduces risks associated with practice failures, and will likely broaden and strengthen the marketplace for buyers and sellers" (Ross, 2019).

Credit banking is not widely adopted but has seen use in Michigan and California. The California Regional Water Quality Control Board North Coast Region approved a water quality framework for the Laguna de Santa Rosa Watershed. In this resolution, credit banking is used for one-year credit life and a 3-5-year banking allowance. However, the program only applies to phosphorus, whose impact is based more on magnitude than timing. In addition, the structure of the Laguna de Santa Rosa traps the phosphorus in the mainstem during critical periods, and the phosphorus is largely produced by internal recycling of accumulated sources and not ongoing discharges. This demonstrates the local nature of when banking may be an effective tool (Mangelsdorf, 2018).

The Great Lakes Commission created "Conservation Kick" in March of 2020 to create a water quality trading program for the Great Lakes Region. It is built following the successes of two demonstration projects: Wisconsin's Fox River Basin and the Western Lake Erie Basin. Under these demonstration projects, credits that were generated from either point or nonpoint sources had to be used or traded within five years of generation or one year after effective compliance. Banked credits could not be used with water bodies with retention times less than one year. If credits were not used within their credit life, they were retired (Graziani, 2007). However, those demonstration projects have now been closed. At the time of this writing, it is unclear whether banking will be allowed under Conservation Kick.

8. Credit Stacking

Credit stacking is the practice by which agricultural sources could receive multiple credits stemming from the same activity through participation in multiple ecosystem service markets. For example, by planting a vegetated buffer, farmers could theoretically get credit for reduction in nutrient runoff as well as for carbon sequestration.

Benefits of stacking include the additional financial incentives for nonpoint sources to participate in nutrient trading markets. Gasper et al (Gasper et al., 2012), for example, found that in the case of high cost BMPs, such as planting forested buffers and wetland restoration, "the financial additionality criterion generated substantially more BMP implementation compared to a scenario where stacking was never permitted. Less expensive BMPs like grass buffers and cover crops were incentivized by the water quality market individually" (Gasper et al., 2012).

Liu and Swallow (Liu & Swallow, 2016) find that offering opportunities to stack credits enhances incentives for nonpoint sources to participate in nutrient markets, creating "thicker" markets that can increase efficiency. They also point out that by ignoring secondary or ancillary benefits (that is, by not allowing stacking), "the focus on water quality production fails to generate incentives to choose among BMPs that may result in higher environmental quality relative to non-water quality features." Unbundling an ecosystem service into its various components (water quality, carbon sequestration, etc.), and not allowing those permits to be sold, could force the supplier to choose between a BMP that supplies a high level of water quality benefits but low carbon sequestration, and a BMP that supplies a high level of carbon sequestration but a low level of water quality benefits. The farmer might then allocate her resources towards the market that yields a better financial outcome.

However, drawbacks of credit stacking include the very real potential of "non-additionality" - in other words, the possibility that nonpoint sources will get credit for water quality improvements that would have occurred without a trading market (see section 5). If too many credits are given for non-additional water quality "improvements," then it is possible for water quality to actually worsen as a result of a nutrient trading market (Liu & Swallow, 2016).

Motallebi et al (Marzieh Motallebi et al., 2018) point out that in a non-competitive market where the seller market is thin (i.e., many buyers but not many sellers), markets could fail to produce the desired results. Moreover, Lentz et al. (Lentz et al., 2014) demonstrate that if pollution activities are "lumpy" (i.e., large and discrete rather than smooth and continuous as is typically the assumption in economic models), water quality could diminish, rather than improve as a result of a trading scheme with stackable permits. They point to certain situations where stackable permits can lead to a desirable outcome: “if demand for the credit covers the majority of the cost of installing [the BMP] and the market of the primary credit is not exhausted” (Lentz et al., 2014).

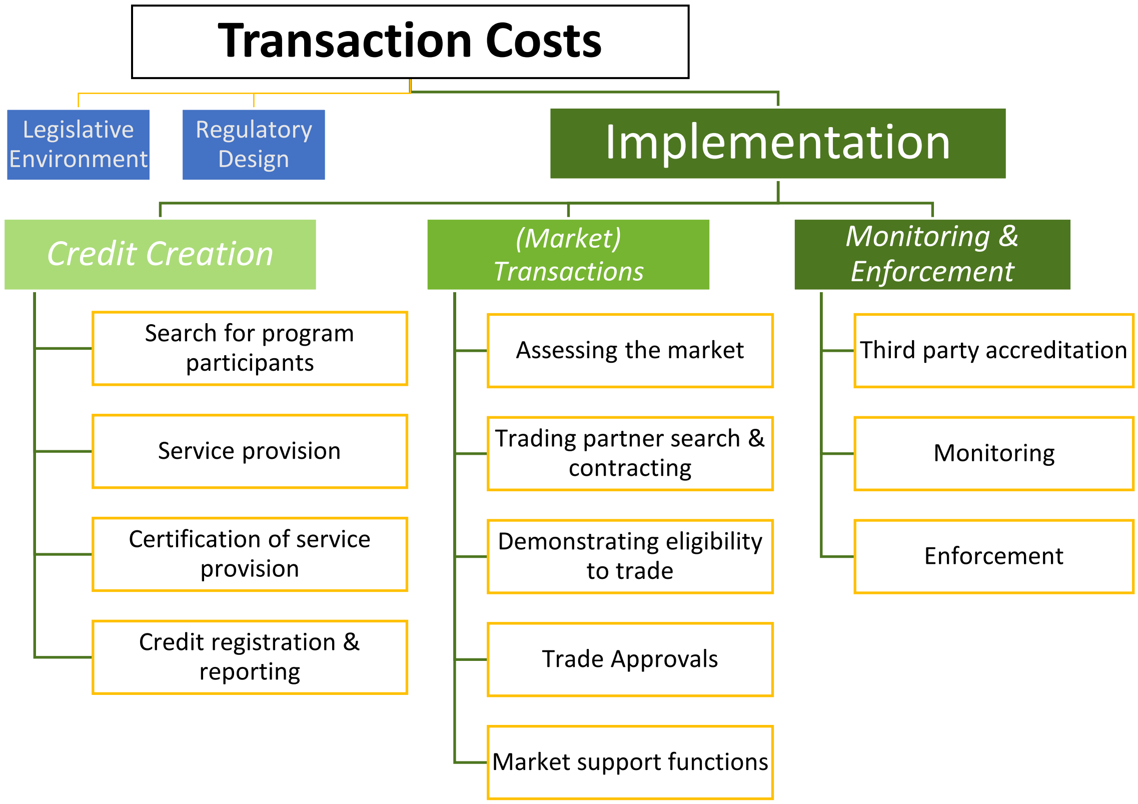
Fox (Fox et al., 2011) pointed out several issues for consideration as regards stackable permits including: that “managing the site for one credit type should not denigrate the ecological values represented by the other credit types”; that “regulatory agencies need the resources and capacity to confirm the ecological validity of the transactions;” that “any stacking and unbundling of credits should be transparent;” and that “tests for additionality should be applied” (Fox et al., 2011).

The EPA’s 2019 memo updating the 2003 Water Quality Trading Policy encourages stacking, as multiple types of credits “may promote more holistic resource improvements” and also “may create additional financial incentives for landowners, conservationists, and innovators to participate in market-based environmental improvement projects” (Ross, 2019).

9. Transactions Costs

Rees and Stephenson (2014) developed a comprehensive conceptual framework for assessing transactions costs in water quality trading programs (figure 2).

Figure 2: Transactions Costs Associated with Water Quality Trading Programs



Source: (Rees & Stephenson, 2014)

This framework classifies transactional costs into costs incurred during credit creation and those incurred during implementation. Transactions costs that fall under "credit creation" may include outreach, "targeting" costs, verifying program eligibility, pre-certification, and registration. Transactions costs generating activities that fall under implementation include not only the types of transactions costs that could be found in a traditional market, but also requirements to demonstrate trading eligibility. Finally, monitoring and enforcement costs "are incurred because of the program administrator's need to ascertain whether the 'link' between the tradeable credit and the underlying environmental service provision is being maintained, and to undertake enforcement actions if it finds that the link is broken. In other words, costs continue to be incurred after sale of the credit to verify the continued existence of the commodity" (DeBoe & Stephenson, 2016). Ignoring or underestimating these costs may undermine program participation (Marzeih Motallebi et al., 2016).

Transaction costs are mostly determined by the structure of a program in terms of how credits are transferred from nonpoint to point sources. Programs that are designed to facilitate trade through monthly or annual meetings or using a third-party broker, along with cost-sharing or government assumption of costs, allow for transaction costs to be lower. Higher transaction costs are attributed to the level of detail required in the application process, how long it takes to be approved, and the complexity of negotiations (Morgan & Wolverton, 2005).

Administrative costs follow a similar pattern as transactional costs but are based around program management. These can be lower when programs are run in a low-cost fashion such as: using preexisting monitoring systems; having point sources bear the burden of the costs, and low levels of bureaucracy in monitoring trades. High administrative costs come from high monitoring costs, extensive application reviews, oversight of nonpoint source BMP implementation, and inspection costs (Morgan & Wolverton, 2005).

One study in North Carolina calculated farmers' "adoption premium: the price they would need to be paid above direct costs in order to participate in a WQT program. The study found that farmers would need approximately double the direct cost in order to participate. While the cost of lawyers and other additional costs contributed to the relative unwillingness to participate, trust and uncertainty played a significant role in decision making. The study found that providing information on the cost structure of the credit improved interest from 27% to 93%, highlighting the role of transparency in supporting participation (Marzeih Motallebi et al., 2016).

The additional costs necessary to entice participation in WQT programs should be considered by policymakers to improve the robustness and efficiency of the market they wish to create. Willingness to participate may also require additional compensation as many participants are skeptical of programs due to trust and uncertainty issues (see section 10). While this cost is larger than policymakers may anticipate it is part of the cost of developing a strong credit generating base and effective WQT for their watershed.

10. Trust, Norms, and Communication

The theoretical model of supply and demand presented in section 1 focuses on quantitative measures such as monitoring costs, marginal cost of abatement, and the like. Less easily quantifiable but still crucial to the functioning of a market are norms like trust and communication, and to some extent, identity.

Matt Mariola, a member of the Environmental Studies Program at the College of Wooster, points out that a water quality trading market is not like other markets:

> The key fact to remember is that the trading of water quality credits between farmers and point source polluters is quite unlike most other forms of market exchange. It is the buying and selling of an invisible commodity by two sets of actors under very different levels of regulatory obligation. From the farmer's point of view it is an act steeped in risk, uncertainty, and even skepticism (Mariola, 2012, p. 579).

Even if other conditions are ripe for exchange – ample demand and ample potential supply – trust between sellers and buyers is a fundamental underpinning of a well-functioning market. Given the sometimes strained relationship between farmers and government, another barrier to the effective supply of permits may exist.

Yet another hurdle exists in the nature of the commodity itself: pollution. Mariola writes:

> The fundamental issue we are dealing with is pollution, with all its moral implications. Farmers are not regulated under the CWA thanks to an exemption of agricultural impacts in 1977, but they are acutely aware of the public perception of farming as polluting. To engage with a WQT program is to explicitly acknowledge the pollution coming from their farms, and, far worse (even if unfounded), to risk increased government scrutiny or the imposition of new regulations on nonpoint source pollution (Mariola, 2012, p. 581).

History and values matter. Breetz et al. (2005) point out that "A strong pride in private property, a history of tensions with industrial actors, or a desire to be recognized for land stewardship are just a few of the attitudes and values that can establish powerful norms of behavior discouraging trades" (Breetz et al., 2005, 172).

Breetz et al., cited above, apply the lessons of social embededness theory to water quality trading programs. They point to three mechanisms through which water quality trading programs could be supported through better communication: education and outreach; third party facilitation; and building on already existing social networks. Results of several case studies suggested that education and outreach work best when motivational constraints are low and where landowners are already receptive to conservation practices. They also point out that educational tactics work best when targeting a relatively small group of landowners. Third party facilitation may be able to overcome trust issues if the third party is seen as unbiased and independent of regulators. And finally, building on already existing social ties may reduce farmers' reluctance to participate in trading.

Breetz et al. cite three broad lessons for water quality trading from their research:

> First, focusing on the social context of economic decisions yields a more nuanced explanation of farmers' reluctance to trade. The normative implication is that providing economic incentives without addressing social concerns will not be sufficient to establish efficient and effective trading programs. Farmers need to be reassured that their long-term ability to farm will not be impaired and that benefits and responsibilities are equitably distributed.
>
> "Second, contrary to neoclassical or neo-institutional expectations that social relations are a frictional drag on the market, embeddedness shows that trusted social relations can facilitate strong communication, promote access to greater trading opportunities, reduce transaction costs and create a more efficient market. The messages above will likely be unpalatable if the communication is perceived as complicated, patronizing, or untrustworthy.
>
> "Third, this efficiency gain is only operative up to a point, after which relying exclusively on social relations can stagnate innovation and close off opportunities (Breetz et al., 2005, p. 175).

Therefore, focusing only on supply and demand to the exclusion of norms and social institutions could be the difference between success and failure when developing a water quality trading program.

11. Environmental Justice / Hot Spots

Point-nonpoint source trading has the potential to exacerbate pre-existing environmental justice issues. The creation of a WQT program that incorporates these types of trades would likely need additional regulations to prevent ill effects from being concentrated in minority and low-income areas. If the goal of a WQT program is to increase water quality across a watershed, concentrations of pollutants due to point sources would undermine program credibility. Issues to account for when constructing a program include making sure that health and environmental impacts do not disproportionately affect minority communities (especially as those communities are more likely to be located near a point source polluter), ensuring that minority communities enjoy the benefits from trading, and making sure communities are fully informed and able to participate in the construction of a program (Steinzor, Verchick, Vidargas, & Huang, 2012).

Mitigation of hot spots created by point sources needs to be factored into any WQT program. An urban waste water treatment plant located in a minority/low income community that is able to maintain or increase pollution levels through trading would disproportionately expose that community, and nearby communities, to water contaminants (Steinzor et al., 2012). Members of lower income communities are more likely to rely on fishing to reduce food costs and ingesting fish from contaminated waters increases their health risks. How the surrounding communities use a water resource should be considered when reviewing a trade from a nearby point source.

The following list, adapted from (Steinzor et al., 2012) includes possible ways to mitigate harm to lower income/minority communities when setting up a trading program.

- Limiting the number of credits that a discharger can purchase as a way of controlling how much pollution is released in a single area.
- Restricting or forbidding the use of offsets. Offset schemes can lead to a disproportionate amount of pollution being emitted in low-income and minority communities. Any plan that involves the use of offsets should be carefully reviewed to prevent any single community from receiving a disproportionate amount of pollution.
- Permanently retiring credits and using a credit ratio greater than 1:1 to lessen pollution overall rather than maintain the status quo of water quality. This would mean that buyers would need to buy more credits than strictly needed to offset their pollution.
- Placing temporal restrictions on credit usage to account for seasonal changes in pollution. Agricultural runoff fluctuates over the course of a year. To mitigate hotspots and stay within TMDLs, trade regulations should account for these shifts and ensure that seasonally created pollution extremes are not exacerbated.
- Imposing restrictions based on geographic location to create a regulatory preference for upstream trades. Upstream trades, where credits are generated through upstream reductions in pollution, can benefit an entire watershed. Downstream trades, where upstream polluters buy credits from downstream generators, can contribute to local water quality violations and degradation to the entire watershed.
- Prioritizing trades that would improve water quality in areas that have been disproportionately affected by pollution.
- Using data specific to the watershed to understand how communities use water resources and thus how they could be impacted by any particular trade. For example, as stated above, lower income/minority communities are more likely to engage in subsistence fishing and consume larger qualities of locally caught fish. The use of national or statewide averages of fish consumption, which is lower than in these communities, would underestimate the health risks of trades.
- Assist in development of green infrastructure. A recent study found that communities in Maryland with high non-white populations and high poverty rates received little to none of the funds set aside for watershed restoration (Dernoga et al., 2015). If a WQT

program is set up in conjunction with a green infrastructure program, the agency running the WQT program should ensure that low-income and minority communities benefit from such programs and assist in community participation.

- Keep communities informed and involved with decisions related to water quality and trades.
- Ensure that trading agencies would be held accountable for failure to provide communities with information about the pros and cons of trading, and accountable for trades that excessively harm a community.

12. Conclusion

The creation of a water quality trading program involves many choices, all of which involve tradeoffs. Setting a baseline "too high" may result in a thin supply of credits, whereas setting it "too low" may have equity implications and lead to non-additionality (further increasing the possibility of hot spots). Similarly, setting the trading ratio too high could result in a lack of demand, as point sources find trading too expensive. Setting the trading ratio too low, however, could result in degraded water quality. Institutions put in place to try and reduce risk and uncertainty could end up increasing transactions costs for both the regulatory agency and the trading partners. The need for trust-building and effective communication could increase costs as well.

The architects of a trading program need to evaluate the goals of their program, consider the tradeoffs carefully, and make choices that would lead toward success, however it is measured. However, given the complexity of such a market, the characteristics of the "commodity" (pollution), and the sensitivity, politics, and judgments that always surrounds environmental issues, a program should be designed to be transparent and flexible.

The National Network on Water Quality Trading outlined six principles that should guide the formation of a water quality trading program. A well-designed program should:

- "Effectively accomplish regulatory and environmental goals;
- Be based on sound science;
- Provide sufficient accountability, transparency, accessibility, and public participation to ensure that promised water quality improvements are delivered;
- Produce no localized water quality problems;
- Be consistent with the CWA regulatory framework; and
- Include appropriate compliance and enforcement provisions to ensure long-term success" (Willamette Partnership et al., 2015)

Success is not guaranteed, even if all of these principles are followed. Recall from Section 1 that three environments are required for a successful trading program: an amenable physical environment, an appropriate economic environment, and a friendly institutional environment. These three conditions are intertwined and interconnected, in that changes to one type environment will change the other two. By creating the conditions under which these environments can thrive, the policy maker can set the stage for a successful program.

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