Nonpoint Source and Carbon Sequestration Credit Trading:

What Can the Two Learn from Each Other?

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Abstract

Emission trading programs have been discussed with respect to achieving water quality objectives and future caps on carbon emissions. A significant part of this literature explores the institutional and technical design issues associated with trades involving nonpoint effluent sources and carbon sequestration. This paper explores conceptual linkages between the nonpoint and carbon sequestration programs and identifies potential areas where cross fertilization can benefit research and policy design of trading programs for environmental protection.

Introduction

Emission and effluent trading programs have been discussed with respect to achieving water quality objectives and future caps on carbon emissions. Policy and academic discussions of water quality trading programs often revolve around trades involving nonpoint sources. In the most frequently cited example of such a trade, a regulated point source discharger (sewage treatment plant or industrial facility) may be able to pay an unregulated nonpoint source (agriculture and/or forestry operations) to reduce emissions in order to reduce on-site regulatory requirements (so called "point-nonpoint" trades). Emission trading is also advanced as a strategy to address climate change. An important element of the carbon trading literature involves designing programs that encourage investments in carbon sequestration activities. A carbon sequestration trade would allow a stationary emission source (e.g. an electric utility) facing a mandatory limit on carbon emissions (existing or future limit) to increase emissions by enhancing the carbon absorptive capacity of the environment by an equivalent amount. Carbon sequestration activities increase the carbon content in soils (no-till cropping systems or improved land management) or increase forest biomass.

While the trading concept is applied to different mediums and different institutional contexts, trading programs involving nonpoint sources and carbon sequestration offsets share many similar features. Both nonpoint and carbon offset trades involve the exchange of pollutant control responsibility between unregulated sources that do not face quantitative mandatory limits on discharges and regulated sources that do face quantitative mandatory limits on discharges. Typically the unregulated sources are land-based sources and are frequently agricultural operations. The trade involves the unregulated source taking actions that reduce its emissions relative to a baseline prior to the trade. The demonstrated reduction beyond the baseline that can then be sold to the regulated source are called credits. In both nonpoint and carbon sequestration credit trades, unregulated sources are characterized by relatively high levels of uncertainty surrounding measurement and monitoring of pollutant discharges. Measurement uncertainty can be reduced by increasing expenditures on monitoring.

While there are many similarities between carbon offset and nonpoint source trading programs, the respective literatures have developed in almost total isolation from each other. There has been almost zero recognition of these similarities in the two literatures and little conscious effort to draw from the experiences and insight from the research and policy discussion surrounding each program. Each literature has developed a unique and separate language to describe the situations and policies of carbon sequestration and nonpoint source credit trades, further hindering opportunities for mutual learning. The purpose of this paper is to explore the conceptual linkages between the two programs and identify potential areas where cross fertilization can benefit research and policy design of trading programs for environmental protection.

The paper first identifies the major themes in each trading literature related to nonpoint sources and carbon sequestration projects. Both policy and academic literatures will be drawn upon to develop these themes. The objective of such a summary is not to provide a comprehensive review of the vast trading literature, but to identify relevant topics that draw the most professional interest and attention. In this summary, the terms that are unique to each program, but that nonetheless describe issues that are common to both, will be identified. Based on these findings, the paper will then elaborate on a number of areas where there is large potential for mutual learning and policy cross-fertilization. Areas of greatest mutual learning include topics that are relevant to both trading programs but nonetheless seem overlooked by one literature and topics for which separate terms and vocabularies are used to describe similar issues.

Nonpoint Source Trading Themes from the Water Quality Literature

Discussions surrounding nonpoint source trading typically centers around three general topics: 1) the legality and enforcement issues surrounding trades between point and nonpoint sources; 2) identifying water quality equivalent trades given different degrees of measurement uncertainty between point and nonpoint source dischargers; and 3) the potential localized water quality problems that arise from trading (local hotspots).

Considerable attention is devoted to the legal issues of applying the trade of nonpoint source effluent credits in the context of the Clean Water Act (American Rivers *et al.* Bartfeld; Chesapeake Bay Program; Fulstone; National Wildlife Federation; Steinzor; Stephenson, Shabman, Geyer; USEPA 2003; 1996; USGAO). Unlike the Clean Air Act, which directly authorizes air emissions trading, effluent trading is never explicitly endorsed within the Clean Water Act. The lack of statutory endorsement creates ambiguities and potential barriers that must be overcome for implementation to move forward. Furthermore, statutory language and regulatory practice surrounding point source permitting (for example "anti-backsliding" and a prescriptive technology-based orientation) create additional implementation barriers. Trades between point and nonpoint sources also raise enforcement issues. Under the Clean Water Act, the nonpoint source faces no mandatory requirement to limit effluent discharges. A fundamental question in a trading program is which trading party assumes the legal and financial responsibility for maintaining the nonpoint source controls and how noncompliance will be enforced.

The topic that tends to dominate the discussions of effluent trading (particularly in the academic literature), however, is the perceived differences in uncertainty concerning measuring effluent discharge of point and nonpoint sources (Bartfeld; Boyd; Crutchfield, Letson, and Malik; Letson; Malik, Letson, and Crutchfield; Randall and Taylor; Ribaudo, Horan, and Smith; Shortle and Horan; Stephenson, Norris, and Shabman). For point sources, effluent emissions are thought to be relatively constant over time and capable of being measured and monitored reliably and at relatively low cost. Measurement of nonpoint source emissions entering water bodies, on the other hand, is complicated by the fact that nonpoint source loadings are inherently stochastic (due to random weather conditions that affect overland runoff) and are difficult and costly to measure (Bosch and Pease).

While direct measurement of nonpoint source loads is often prohibitively costly, quantification of nonpoint source loads is necessary for trading. Given the difficulty of measuring individual nonpoint source loads, the typical solution is use simulation models to estimate the effluent reducing effectiveness of particular control technologies and practices (Shortle and Horan). Modeling nonpoint source loads simplifies nonpoint source monitoring because monitoring can be focused on observing technologies and best management practices rather than actual effluent loads. Yet, this solution does not eliminate uncertainty surrounding nonpoint source discharges since there is there is imperfect knowledge about the relationship between effluent loads and control technologies.

Thus, the overriding concern with effluent trades involving nonpoint sources is that “one must attempt to trade known and measurable point source loads against uncertain nonpoint source load levels” (Bartfeld, 90). Participants in this literature use point-nonpoint trading ratios as a policy alternative that will allow trade to occur with heterogeneous discharges (Randall and Taylor). A trading ratio simply identifies the amount of estimated nonpoint source credits that must be exchanged for a single unit change in point source discharges (Malik, Letson, and Crutchfield). A 2:1 ratio, for example, requires that the reduction in nonpoint source discharges must be two times greater than the corresponding increase in point source discharges. All policy guidance and nearly every proposed or actual trading program involving point and nonpoint sources recommend or use trading ratios to account for differential levels of uncertainty (USEPA 2003; 1996; Cheaspeake Bay Program; Woodward).

Finally, effluent trading programs must address the fact that discharges are not uniformly mixed. Each individual discharge enters receiving waters at a specific location and could potentially have local and regional water quality impacts. If each discharge source is considered as having unique water quality consequences, the effluent trading programs cannot occur. Trading requires that effluent loads be relocated within a defined area. Potential economic efficiencies increase as trade opportunities expands. The design and debate of effluent trading programs constantly struggles with the trade-off between increasing the geographic scope of trades (in the name of economic efficiency) and reducing the geographic reach of trades because of the potential for adverse localized impacts (“hotspots”) (National Wildlife Federation; Bartfeld, Chesapeake Bay Program; USEPA 2003; 1996).

Carbon Sequestration Credit Trading Themes

The international concern for global warming and the policy responses to it have produced a vast literature. The 1997 Kyoto Protocol identified Annex I (industrial) countries that pledged to reduce their emissions of greenhouse gases (GHGs) to 5.2 percent below 1990 levels (IISD Linkages). Annex II countries (developing) were not assigned caps on their GHG emissions. The Kyoto Protocol also laid out options in which Annex I countries could meet their treaty obligations through investments in carbon sequestration activities in both Annex I and II countries. The literature related to the design and implementation of carbon sequestration for mitigating greenhouse gas emissions can be grouped into three areas: 1) baselines; 2) certification of tradable units (credits); and 3) leakage.

Carbon sequestration credits are generated by parties or sources that face no binding or mandatory emission limit and are bought by parties that face a mandatory cap on GHG emissions. This is true regardless whether an Annex I country sponsors a carbon sequestration project in an Annex II country or whether a regulated industrial sector (electric utilities for example) purchases credits from a domestic agricultural or forest operation. Without a formal system that defines the *ex ante* allocation of GHG emissions control responsibilities to dischargers, *ex post* systems of documenting net changes in GHG emission must be created for carbon sequestration projects.

The first challenge in the carbon sequestration credit creation process is to define a baseline. A baseline is the net carbon emissions (GHGs sequestered less GHGs released) from which the reductions from a carbon sequestration project are calculated. The difference between baseline emissions and sequestration project emissions are considered the "additional" (called "additionality") sequestration and subject to formal crediting. Conceptually, baselines could be based on historical, current, or future emissions. Within the carbon sequestration literature, the definitions of baselines are forward looking and defined with respect to what would have occurred in the absence of a specific carbon sequestration project (sometimes called "business-as-usual"). This general approach to baselines is adopted in order to reduce the possibility that a buyer will purchase carbon reductions that would have occurred without a trade. For example, lower impact logging techniques may become more profitable over time, leave more remaining biomass, and be economical to adopt without a carbon sequestration trade which promotes this activity. In such case, historical baselines would overstate the amount of carbon sequestrated

(Chomitz). While no operational approach to defining baselines exist, considerable attention have been devoted to investigating alternatives (Bailey, Jackson, Parkinson, and Begg; Brown and Hall; Chomitz; Hutchins *et al*.; Laurikka; Murray, Pattanayak; Sommer, Andrasko).

Considerable interest and attention is devoted to mechanisms to certification of carbon sequestration credits. The discussion of certification involves a number of activities, including measurement, verification (monitoring) and duration (King; Moura-Costa and Stuart; Moura-Costa, Stuart, Pinard, and Phillips). Measurement involves identifying the physical changes in GHG emissions from an established baseline. Measurement is usually done directly using biomass measurements like tree height and width and soil sampling rather than indirectly based on model estimates (Moura-Costa and Stuart). Measurement is complicated by the fact that carbon sequestration projects may involve estimating changes in multiple types of GHG emissions (for example CO_2, N_2O, CH_4). For example, improved pasture management stores more carbon in soil but also reduces methane emissions by cows. Additional wetland forest biomass may sequester additional carbon but increase methane emissions. In addition to the vast technical literature on measurement (for examples see Tipper and De Jong), economists have contributed by examining cost effective measurement and sampling strategies (Mooney *et al*.).

Verification and monitoring activities are intended to check the validity of the claims made by credit suppliers. Verification includes calculations of additionality, consistency with treaty requirements, and monitoring of claimed gains. Ongoing efforts are being made to establish verification procedures and standards and numerous organizations now vie to provide third-party verification for carbon sequestration projects (Moura-Costa, Stuart, Trines; Vine, Sathaye, and Makundi).

An issue related to measurement is project duration. Duration identifies when carbon is sequestered and for how long carbon remains sequestered. Potentially units sequestered sooner are more valuable since they result in earlier reduction of warming. Yet, durability may be less than expected due to unforseen natural or human actions. For example, a forest may be destroyed by a fire releasing sequestered carbon sooner than anticipated or performance of crops or trees in sequestering carbon may fall below expected levels due to unanticipated weather events such as drought. The effects of time on value of units is important because firms or countries may wish to bank or borrow credits (Mullins and Baron). Units sequestered permanently are more valuable than units which are sequestered for only a short time. How duration is measured and how trading designs address the question of duration are important elements in the literature (Feng, Zhao, and Kling; King; Tipper and DeJong)

Finally, leakage refers to the unintended increase in net carbon emissions when a project is implemented (Aukland, Moura-Costa, and Brown; Chomitz). Leakage may be categorized as primary and secondary (Aukland, Moura-Costa, and Brown). Primary leakage is displacement of the greenhouse gas reductions to other activities. For example, preserving forest in one location may result in cutting more forests elsewhere. Since the forest preservation activity is accounted for in calculation of a carbon credit but the subsequent cutting of forest is not, the total net reductions in emissions is less than what was transferred in a credit exchange. Secondary leakage is the creation of incentives to increase emissions elsewhere. Secondary leakage depends on availability of substitutes and other factors affecting demand and supply elasticities. For example, reforestation projects may increase timber supplies, reduce prices, and increase consumption (Aukland, Moura-Costa, and Brown). Considerable attention is devoted to estimating the possible extent of the leakage problem and to identifying policy mechanisms to reduce the potential for leakage (Bernstein, Montgomery, and Rutherford; Mullins and Baron; Murray and McCarl; Paltsev).

What Can The Two Literatures Learn from Each Other?

At one level, the carbon sequestration emission and nonpoint source water quality credit trading programs seem vastly different. Scale differences are immense. Land-based carbon sequestration most often occurs within the context of large-scale individual and regional projects that potentially have general equilibrium economic impacts. By contrast, nonpoint source trades typically involve implementation of specific practices and technologies on relatively small parcels of land. Furthermore, nonpoint source trading is limited in scope to regional or local areas because of concerns of creating adverse local water quality effects. Trading programs involving greenhouse gases are truly global. The global and long-term nature of global warming virtually eliminates the concern for localized hotspots of GHG emissions.

Yet, the brief review of thematic areas in the nonpoint source and carbon sequestration literature also demonstrates a number of common areas of interest. The remaining portion of this paper will focus some of these common areas on interest but nonetheless either have not been mutually acknowledged or addressed.

Measurement Uncertainty

Assuring equivalency between the amounts of pollutant being discharged between two types of sources is fundamental to both carbon and water quality trading. Both carbon and water polluting emissions from land based activities are difficult to predict and measure because they are diffuse, subject to long lags, and influenced by stochastic events. Yet, the two literatures have approached these physical characteristics quite differently.

The water quality trading literature has recognized the differences in measurement certainty primarily through trading ratios. Randall and Taylor have noted that this focus has come largely at the neglect of increasing attention to improving monitoring and measurement of nonpoint sources. While measurement uncertainty between discharge sources is acknowledged in the carbon sequestration literature, it is not viewed as a large barrier to market development (Zeuli and Skees). Discussion and debate in the GHG trading literature center on improving the reliability and verifiability of carbon sequestration projects. The emphasis in the GHG trading literature is on institutional designs to provide credit certification and market methods to mitigate risks (for example insurance schemes).

The nonpoint source literature can benefit from focusing attention on policy mechanism that can increase the confidence and reduce measurement error around nonpoint source discharges (Stephenson and Shabman). The carbon literature offers a readily available literature that can be used to draw lessons on policy options like third party certification, insurance mechanisms, and direct measurement sampling protocols can be used to reduce measurement uncertain and encourage a more performance based system. Similarly, the nonpoint source literature contains some conceptual work on the establishment of trading ratios that would be equally transferable and applicable.

2. Baselines

The carbon sequestration literature pays a great deal of attention to the definition of baselines from which changes in carbon sequestration are measured and the effects of baselines on the effectiveness of carbon sequestration and incentives for participating in carbon sequestration. The nonpoint source literature has given the issue less attention. To the extent the issue is examined, it is referred to as initial allocations of pollution rights. Letson mentions initial allocation but focuses discussion on its impact on product markets. The EPA Water

Quality Trading Statement (2003) only mentions baselines in one paragraph and states (2003, 5) "baseline for nonpoint sources should be the level of pollutant load associated with existing land uses and management practices that comply with applicable state, local, and tribal regulations."

The concern with establishing GHG baselines is centered around providing a marketable credit to an activity that would have occurred in the absence of a trade. The same concern is applicable to nonpoint source credit trades. Some BMPs which might be adopted as part of nonpoint source trades (nutrient management, minimum tillage, and integrated pest management, for example) may be equally or more profitable than the corresponding conventional practices (Van Dyke et al; Bosch and Pease). Farmers who participate in trades may have planned to adopt such practices even without the trading incentives. Depending on how baselines are set, farmers who have already adopted such practices may receive trading credit for them, in which case the trade does not bring additional progress toward the water quality goal. Clearly, the nonpoint source policy design might be improved by examining the various approaches used in the carbon sequestration literature to establish baselines.

3. Leakage

A key area of professional and policy interest in the carbon sequestration literature involves accounting issues, particularly the potential problem of leakage. When uncertainty is addressed in the GHG trading literature, it is more often than not in reference to the uncertainty surrounding net changes in emission that arises from the leakage potential of a particular project or policy design. Interestingly, the nonpoint credit trading literature never uses this term. Even the concept is rarely mentioned and when the concept is broached it is raised almost in passing without careful analytical attention.

The potential regional economic impacts of large scale carbon sequestration contributes to the interest in leakage in the carbon trading literature. The small scope and scale of potential nonpoint source trades, on the other hand, effectively eliminate the concern for what is called secondary leakage for effluent trading. Yet, a trade involving uncapped nonpoint sources creates a real potential for primary leakage. Nonpoint source pilot trades and discussions often revolve around the implementation of agricultural or urban best management practices. In such a setting, leakage can occur when a discharger receives credit for reducing effluent loads by installing a practice while increasing loads at another source. Leakages can occur at both the intensive and extensive margins of farm production.

A extensive margin leakage occurs, for example, if a farmer takes bottomland cropland acres out of production to install a forest riparian buffer while expanding production to upland areas that were formerly forested or in conserving uses. The nutrient removal effectiveness of the buffer could be calculated assuming remaining land use remains in the current state. Expanding production to marginal upland soils potentially increases nutrient and sediment losses but such a change is unlikely to be considered in the calculation of a credit. The result is failure to achieve the net reductions claimed by the credit supplier and is no way conceptually different from the concept of primary leakage used in the carbon sequestration literature.

Intensive margin leakages could result if other parts of the farm are operated more intensively as a result of the trade. For example, preliminary results from ongoing research at Virginia Tech (Bonham) indicate that under some circumstances, nutrient management plans can actually worsen nutrient runoff problems. Nutrient management plans may be worded to require that nutrients applications be limited to rates sufficient to obtain realistic yield goals. Farmers who have large amounts of manure nutrients to dispose of may choose to substitute more erosive and runoff-prone rotations (such as corn silage-ryelage) for less erosive rotations (such as hay) because corn silage-ryelage can utilize higher nutrient applications. Even though the corn silage and ryelage rotation may be less profitable than hay on certain soils, the nutrient management restriction can make it more profitable if the alternatives (ship manure off the farm or reduce livestock production) are more expensive.

Research and policy discussion could be devoted to investigating potential for primary leakage in nonpoint source trades and methods to reduce leakages. For example, is it feasible to base nonpoint source trades on pollution-reduction performance at the farm level rather than changes in management practices for specified enterprises? Farmers who enter trading agreements might be required to file total farm plans with detailed practices. Such management practices could be used with spatial databases and simulation models or nutrient budgets to estimate farm level emissions before and after trading. Potential leakages could be reduced but at a cost of higher transactions costs for monitoring and enforcement.

4. Trade Flexibility

The carbon emission trading literature covers an expansive range of opportunities to reduce GHG concentrations in the atmosphere. The potential to reduce multiple types of GHG pollutants is considered and attention is paid to identifying equivalent heat trapping potential of multiple GHGs including carbon dioxide, nitrous oxides, and methane. Furthermore, trading of multiple GHGs is not only seen as a way to manage the discharge of GHGs into the atmosphere, but also as a way to increase the capacity of natural systems to assimilate GHGs. The expansive sequestration literature demonstrates that desirable environmental end states can be accomplished by other means than reducing source emissions.

By contrast, the policy and professional attention devoted to nonpoint source credits trading tends to be more narrowly focused on trades involving reducing emissions for a single pollutant. Such a narrow focus is not necessary. Effluent trading programs are ultimately aimed at achieving a designated use for water bodies. This designated use may be affected by multiple pollutants and multiple stressors. Changes in BOD, N and P may all affect the potential of a waterbody to meet its designated use in terms of supporting aquatic life, recreation, and aesthetics. Cross pollutant trading could be a practical alternative in many watersheds. For example, can reductions in BOD demand by some sources compensate for increased N loads by other sources?

Carbon sequestration is based on trading increased assimilative capacity in some sources for increased emissions from other sources. The nonpoint source literature has had little to say about these types of trades for water quality purposes. For example, oysters can efficiently filter nutrients out of water and the nutrients can be removed from the waterbody (Santopietro, Shabman and Stephenson). Another possibility is to introduce oxygen into water at strategic points such as dams in order to increase the assimilative capacity of the stream (Crossman and Ruane) or increase the pollutant dilution potential of a river system through flow augmentation. Additional empirical research can investigate whether it is more cost effective to compensate oyster farmers or dam operators for increasing the assimilative capacity of water bodies than to pay crop farmers to reduce their nutrient applications or install buffers. More importantly perhaps, insights into the design and certification of assimilative capacity credits are already available in the carbon sequestration literature.

Conclusions

Increased attention to the similarities and differences between carbon emissions and water quality trading can lead to new insights about policy and institutional design with implications for a wide range of resource policy issues. Areas where potential exists for cross fertilization include measurement uncertainty, baselines, leakage, and trading flexibility. The knowledge gained could be used to improve and expand trading programs with resulting increases in environmental quality.

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