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Covariant Risk and Nutrient Credit Training

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COVARIANT RISK AND NUTRIENT CREDIT TRADING

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Every summer, a dead zone is created in the Chesapeake Bay. The dead zone is created by too much of a good thing: nutrients, especially nitrogen and phosphorus. The largest source of excess nutrients in the Chesapeake is agriculture; manure and artificial fertilizers are washed into streams that eventually reach the bay.[1] In the bay, nitrogen and phosphorus create an algae bloom, which consumes all the dissolved oxygen. Some fish escape, but other creatures expire in this dead sea within the Chesapeake Bay.[2]

To reduce the excess nutrients reaching the bay, several states are experimenting with nutrient credit trading.[3] A large part of the appeal is political: Nutrient credit trading is popular in an ideological climate hostile to regulation. Part of the appeal is a response to policy success. Pollution trading reduced acid rain at low costs, which raised hopes that environmental markets can produce outsized benefits at low costs. To date, nutrient credit trading has disappointed and it is likely to continue to disappoint. Better market design cannot remedy the inherent defects in nutrient credits. This Article identifies previously unidentified defects in nutrient credit markets, contributing to an already large literature on the shortcomings of nutrient credit trading. This Article adds to the weight of mounting evidence that nutrient credit trading cannot deliver improvements in water quality.

I. WHY NUTRIENT CREDIT TRADING?

The enthusiasm for environmental markets in general, and nutrient credit trading in particular, does not rely solely on their merits. The intellectual climate in academia and the political climate in government has been hostile to direct government regulation for several decades. In a policy environment where government mandates are disfavored and all things "market" are favored, nutrient credit trading is an attractive answer to

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1. U.S. ENVTL. PROTECTION AGENCY, CHESAPEAKE BAY TOTAL MAXIMUM DAILY LOAD FOR NITROGEN, PHOSPHORUS AND SEDIMENT 4–29 (2010) [hereinafter CHESAPEAKE TMDL].

2. *Id.* at ES-3.

3. In addition to Pennsylvania, Maryland and Virginia have nutrient credit trading schemes. MD. CODE REGS. 15.20.12 (2016); VA. CODE ANN. § 62.1-44.19:12 (West 2005).

poor water quality. While all markets depend on government to some degree, environmental markets are entirely creatures of regulation since the goods traded are valuable only to the extent that the goods allow the owner to avoid government sanction. The political and intellectual appeal of environmental markets received a significant boost by the success of the market for sulfur dioxide and nitrogen oxides.[4] The ideological appeal of "market" solutions cannot entirely explain the current enthusiasm for nutrient credit trading. Instead, the current fervor for nutrient credit trading is partly the result of the political power of farmers, coupled with a trend towards disguised taxation.

There are two reasons why requiring farmers to reduce the flow of excess nutrients is difficult. Most importantly, farmers have political power disproportionate to their numbers or wealth. The second reason is that excess nutrients in the stream are invisible, at least until the inevitable algae bloom. The dead zone in the Chesapeake Bay is not visible from land, let alone from Pennsylvania. Furthermore, the contribution of any individual farm is both small and cannot be distinguished from other sources of excess nutrients.

Excess nutrients are not an inevitable byproduct of agriculture. Rather, they are the result of specific choices made by farmers to grow certain crops in a particular way. Better management practices would retain nutrients on the farm and thus out of the stream, but many of those practices are costly. Farmers will lobby against rules requiring better farming practices, especially if the practices are expensive, but even if the practices are merely novel. Thus, government believes it cannot require farmers to protect water quality. Instead, nutrient credit trading enables government to bribe farmers to adopt better management practices.

Maryland raises the revenue to fund bribes to farmers (and others) transparently. Maryland imposes a "flush tax" of sixty dollars on each sewer bill with the revenue dedicated to water quality projects. Municipalities receive money to upgrade waste water treatment plants. Homeowners receive money for septic tanks that retain nutrients. Farmers are paid to plant cover crops, a better management practice that retains sediment and nutrients in the field.[5]

In contrast, Pennsylvania has chosen to disguise the taxes necessary to fund the bribes paid to its farmers. Nutrient credit trading does not impose

4. The U.S. Environmental Protection Agency established a market in pollution credits in the Acid Rain Program under the authority of the Clean Air Act Amendments of 1990. 42 U.S.C. § 7651 (2012); *see e.g.*, *The Invisible Green Hand*, ECONOMIST (July 4, 2002), http://www.economist.com/node/1200205 (calling the Acid Rain Program the "greatest green success story of the past decade").

5. 2012 Md. Laws 927, 933–38.

a direct charge on either taxpayers or water ratepayers. Instead, the costs imposed are distributed by the sale of nutrient credits, which disguises both the amount and the ultimate recipients. In a nutrient trading scheme like Pennsylvania's, the buyers of nutrient credits are developers and waste water treatment plants. Both developers and waste water treatment plants will shift the costs onward. Developers are not charities; whatever costs are imposed on the construction of new homes are ultimately borne by the buyers of new homes. Waste water treatment plants run by private entities will similarly shift the cost to ratepayers. Even public waste water treatment plants must cover their costs, so the cost of buying nutrient credits will be shifted to ratepayers. Instead of a transparent tax on each user, new homes will be more expensive and water bills will be higher, concealing the true burden of the scheme. Farmers are expected to be the largest source of nutrient credits and thus the ultimate recipients of much of this redistribution through disguised taxation.

Although several other states in the Chesapeake watershed do operate nutrient credit markets, Pennsylvania is particularly worthy of attention. Even though Pennsylvania does not border the Chesapeake Bay, its impact is outsized because of its share of the land area of the drainage and its large number of farms, especially dairy farms. Each year, the manure from a single dairy cow includes more than 360 pounds of nitrogen and 60 pounds of phosphorus.[6] Roughly half the farms in the Chesapeake watershed are in Pennsylvania. The nutrient pollution in the Susquehanna has a greater effect than pollution elsewhere in the Chesapeake watershed.[7] Pennsylvania contributes forty-four percent of the nitrogen and twenty-four percent of phosphorus flowing into the Bay.[8] The next largest contributor of nitrogen to the Bay is Virginia, which is responsible for twenty-seven percent of the total.[9] Of the excess nutrients contributed by agriculture, Pennsylvania contributes more than half the nitrogen and a quarter of the phosphorus.[10] Thus, Pennsylvania's nutrient credit trading program deserves special scrutiny, given its importance to the Chesapeake.

In Pennsylvania, the Department of Environmental Protection ("DEP") oversees nutrient credit trading, including certifying credits.[11] Most buyers of nutrient credits hold National Pollutant Discharge Elimination System

6. UNIV. OF CAL. COOP. EXTENSION, MANURE TECHNICAL GUIDE SERIES: DAIRY MANURE NUTRIENT CONTENT AND FORMS (2009).

7. CHESAPEAKE TMDL, *supra* note 1, at ES-7 tbl. ES-1; ES-6 fig. ES-2. For contribution by watershed, see *id.* at 4-3 to 4-4 figs. 4-4, 4-5 & 4-6.

8. *Id.* at 4-1 to 4-2 figs. 4-1, 4-2 & 4-3.

9. *Id*. Virginia, however, does contribute more phosphorus than Pennsylvania. *Id.* at 4-2 fig. 4-3.

10. *Id*. at 4-5 fig. 4-1 & 4-2.

11. 25 PA. CODE § 96.8 (2010).

("NPDES") permits.[12] The U.S. Environmental Protection Agency ("EPA") has delegated the authority to issue NPDES permits to DEP, but retains authority to police the permits. Nutrient credit trading in Pennsylvania began in 2004, predating the EPA's determination of Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment ("TMDL").[13] As of 2017, Pennsylvania is likely to miss its pollutant reduction targets under the Chesapeake TMDL. Waste water treatment plants are on-track to meet their targets, whereas agriculture is not.[14]

II. RECOGNIZED CHALLENGES

The literature on nutrient credit trading has identified several shortcomings. The first problem is verification, since the returns to fraud are significant. Secondly, trading between point sources and nonpoint sources presents the possibility of regulatory arbitrage and reduced compliance. Thirdly, establishing a market in nutrient credit requires establishing a baseline that determines which activities generate credits. Setting the wrong baseline can impede the development of a market in nutrient credits or produce smaller than anticipated environmental benefits. Lastly, many environmental markets establish trading ratios between different nutrient credits, which can similarly hobble market development.

Ensuring the validity of nutrient credits is a significant and persistent problem. Nutrient credits are valuable and thus there is money to be made in faking them. Ordinarily, buyers police the quality of the goods themselves. Thus, supermarkets do not sell counterfeit avocados because customers can tell the difference and prefer an actual avocado to papier-mâché or plastic replica avocados. But, no one buys a nutrient credit for themselves since the nutrient credits have no value to the buyer except to satisfy a government mandate. If there is no or low risk of detection, buyers will prefer cheaper counterfeit credits to more expensive real credits. In this way, nutrient credits are analogous to engagement rings. Generally, the fiancé buys the ring for his fiancée. If an unscrupulous jeweler offered him a counterfeit diamond for less, he would prefer that,[15] assuming his deception would not be discovered. The ring has no value to him; its only value is to the third party.

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12. 33 U.S.C. § 1342 (2012) (establishing a national permit program for the "discharge of any pollutant, or combination of pollutants").

13. U.S. ENVTL. PROTECTION AGENCY, PENNSYLVANIA'S TRADING AND OFFSET PROGRAMS REVIEW OBSERVATIONS 9 (2012).

14. U.S. ENVTL. PROTECTION AGENCY, INTERIM EVALUATION OF PENNSYLVANIA'S 2016–2017 MILESTONES PROGRESS 1 (2012).

15. To readers who are the author's wife: he did not do that.

Even if government can prevent the trading of counterfeit nutrient credits, low-quality credits will come to dominate, reducing the overall environmental benefit. Nutrient credits are akin to money, since these credits are both a medium of exchange and a measure of value.[16] Like money, nutrient credits are subject to Gresham's Law. Gresham's Law is a principle of monetary economics that "bad money drives out good."[17] But here, the mechanism is somewhat different. When money was coin, people would hoard coins with more gold or silver and spend coins with less valuable alloys. In the market, bad money (with little gold or silver) would drive out good money. The mechanics of Gresham's Law in nutrient credits are different, since credits expire at the end of the water year, which limits hoarding. Yet, a similar dynamic operates since all nutrients are not the same quality, just like coins. Here, lower quality means the credit represents a smaller or less certain environmental benefit. Lower-quality credits will often be cheaper to generate and thus undercut high-quality credits on price. So long as buyers do not distinguish between the quality of credits, the cheapest credits will dominate the market. If the cheapest credits are also low quality, the worst credits will outcompete nutrient credit of higher quality.

All environmental markets suffer from verification problems, but nutrient credits are more susceptible for two reasons. First, the number of sellers is greater than in other pollution credit markets.[18] There are 84,000 farms in the Chesapeake watershed.[19] Even if a small share of farms generates credits, the number of credit generators would be large and thus the cost of verification would be colossal. Second, many of the agricultural practices that generate credits are difficult to monitor. Some agricultural practices, like riparian buffers, can be monitored somewhat cheaply. A single site visit can confirm the existence of a riparian buffer; infrequent trips back to the farm can confirm whether the buffer has been damaged by heavy rain or grazing. In contrast, some agricultural practices require essentially continuous monitoring to confirm whether nutrients are being

16. Nutrient credits do not satisfy the third characteristic of money since these credits are not a good store of value. Credits expire at the end of the water year and so do not hold their value.

17. Although named after Sir Thomas Gresham, the process has been observed many times since the advent of money. *See, e.g., The Frogs* by Aristophanes, *in* THREE GREEK PLAYS FOR THE THEATRE 173 (Peter D. Arnott ed., trans., 1961).

18. The Acid Rain Program applies to 1226 facilities for SO_2 and 336 facilities for NO_x, but the number of entities trading is much smaller since most firms own many facilities. Less than a fifth of trades of SO_2 are between separate entities; the rest are related-party transactions. U.S. ENVTL. PROTECTION AGENCY, 2015 Program Progress—Cross-State Air Pollution Rule and Acid Rain Program 14, 52 (2015).

19. U.S. DEP'T OF AGRICULTURE, CHESAPEAKE BAY 2011 ACTIVITIES REPORT 1 (2011). EPA estimates a slightly higher figure of 87,000 farms. CHESAPEAKE TMDL, *supra* note 1, at 4-29.

kept out of the stream. For example, manure spreading or tillage practices would need to be monitored throughout the year. Farmers generate credits when manure or fertilizer is applied at rates below agronomic rates in the current Penn State University Agronomy Guide.[20] Thus, verifying the nutrient credit means monitoring the amount and the timing of manure application, not just whether manure was applied or not.

Verification problems are largely a problem of nonpoint sources. Point sources are much better positioned to generate credits of high quality because these sources maintain ongoing monitoring of their discharge. Waste water treatment plants can generate nutrient credits when those plants remove more nutrients than required by law. Plants can generate cleaner water than required by investing in better equipment or running the plant differently, which is costly. If a waste water plant exceeds the regulatory baseline, that excess represents a reduction in nutrients being returned to the stream and thus is a credit. Absent outright fraud and record falsification, waste water treatment plants generate nutrient credits of high quality because nutrients in the water discharged are already monitored continuously.

Among nutrient credits generated by nonpoint sources, hauling poultry manure outside of the Chesapeake watershed presents the smallest verification problems. Unlike swine and cattle manure, poultry manure is dry, which makes hauling economical since the amount of nitrogen and phosphorus is high relative to the water content and thus the weight of the load. The trucks can be weighed leaving the farm and arriving at the destination, where the poultry manure is applied according to a nutrient management plan.[21] Generally, the main destination for poultry manure are reclaimed mining sites where fertilizer would be applied anyway to encourage re-growth, which also controls erosion.

Trading between point and nonpoint sources is generally expected to constitute most of the activity in nutrient credit markets. In fact, it is often the rationale. Many point sources have already taken all the cheaper steps to reduce their discharges. Any further improvements in water quality are more expensive. In contrast, nonpoint sources have taken fewer steps, leaving more of the cheaper steps still to be done. Thus, the cost of reducing nutrients in the stream from the typical nonpoint source is cheaper than from the typical point source. For a point source, it is generally cheaper to pay a nonpoint source to reduce its nutrient contribution to the stream than it is for the point source to make further nutrient reductions in its discharge.

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20. 25 PA. CODE § 96.8 (d)(3) (2010).

21. PA. DEPT. ENVTL. PROTECTION, PHASE 2 WATERSHED IMPLEMENTATION PLAN NUTRIENT TRADING SUPPLEMENT 8 (2016).

Trading between point and non-point sources presents the risk of regulatory arbitrage. As the locus of nutrient reduction shifts from regulated point sources to unregulated nonpoint sources, the ability of non-government actors to monitor and help enforce environmental law is weakened. The Clean Water Act permits citizen suits against point sources that do not comply with a standard, limit, or order.[22] Trading, however, undermines this remedy by shifting compliance from point to nonpoint sources. If a waste water treatment plant failed to comply with a standard, limit, or order, an affected citizen could sue the plant. Instead, if the waste water treatment plant buys nutrient credits that do not represent real environmental benefits, there is no potential for a citizen suit. A citizen suit is not permitted against the nonpoint source, even if that source produces a defective credit, which means that the point source credit buyer is noncompliant. Unfortunately, there is no way to determine whether trading has produced regulatory arbitrage without knowing how many credits are defective, which is difficult because of verification problems already discussed.

A third problem that nutrient credit trading faces is the challenge of setting the baseline. Since nutrient credits represent reductions in nutrients beyond the baseline, the regulator must determine a baseline before any credits can be generated.[23] The baseline identifies a number, or set of numbers, from which all credits are calculated. All nutrient credits are measured from this baseline; the baseline is the zero in the number system.

If the baseline is set too low, a nutrient credit is cheap to generate. Farmers, like other producers, generally know their own costs and thus prioritize, taking the easiest and cheapest steps first and leaving the more difficult and expensive steps until later. But, each credit generated from a low baseline represents a small environmental benefit. Sellers generate many credits and credits are cheap, but the environmental benefit is smaller since the starting point was set low. Thus, a low baseline is good for nutrient credit trading since credits are cheap and plentiful, but bad for the environment. Since improvement in water quality is the goal and nutrient credit trading is only the means, a low baseline elevates the process at the expense of the goal.

Conversely, a high baseline means that sellers cannot generate credits by taking cheaper and easiest steps. Instead, sellers can only generate credits by taking more difficult and expensive steps to reduce their pollution even more. Under a high baseline, sellers will find credits expensive to

22. 33 U.S.C. § 1365 (2012); *see also* 40 C.F.R. §§ 135.1–135.2 (2016) (providing notice and standing requirements for citizen suits).

23. Pollution credits do not depend on a baseline. Instead, the regulator decides how much pollution to permit and then distributes or auctions shares of the total permitted pollution.

generate. Each nutrient credit will represent a larger environmental benefit. Yet, the high baseline will deter many sellers from participating because each credit is too expensive to generate.[24] If sellers do not participate, the anticipated environmental benefits may not materialize.

Pennsylvania has set a high baseline, at least relative to actually existing farm practices. A high baseline discourages farmer involvement and means that nutrient credits are expensive. In Pennsylvania, the baseline is set at the management practices required by state law. Farmers must comply with management practices set by four different statutory requirements: erosion and sediment control, pollution control, nutrient management, and concentrated animal feeding operations, if applicable.[25] In addition, there are specific requirements for riparian buffers and fertilizer application.[26]

Sellers must show that their farm exceeds the legal standard to generate a credit. At first blush, asking farmers to follow the law before being rewarded does not seem like a high baseline. Yet, the lack of enforcement by the state and the lack of compliance by farmers means that minimum standards set by state law are actually a high baseline to set. State management practices are observed in the breach, meaning that most farmers cannot generate credits without first spending significant resources to meet the state standard. Only the portion of the improvement that exceeds the state standard generates a marketable credit. Before generating a single nutrient credit, a farmer would have to take expensive steps to bring their agricultural practices into compliance with state law, but these laws are not enforced. All the expense of meeting the state agricultural standards falls on the farmer since no credits are generated. Thus, the cost of generating nutrient credits is high for many farmers.[27]

Some environmental markets set a trading ratio between different credits. Trading ratios are supposed to compensate for the uncertainty associated with nonpoint nutrient control or allow for trading one pollutant for another. Additionally, trading ratios can be used to adjust for differences where the pollution is introduced or between different pollutants. For example, upstream pollution could be treated more leniently than downstream pollution because less of the upstream pollution will reach

24. Gaurav Ghosh et al., *Baseline Requirements Can Hinder Trades in Water Quality Trading Programs: Evidence from the Conestoga Watershed*, 92 J. ENVTL. MGMT. 2076, 2083 (2011).

25. 25 PA. CODE § 96.8 (d)(2) (2010).

26. 25 PA. CODE § 96.8 (d)(3) (2010).

27. If Pennsylvania enforced its state agricultural standards, then farmers would already meet the standard and any improvements beyond that would generate nutrient credits. Of course, if Pennsylvania enforced its agricultural standards, there might be less need for nutrient credit trading.

the bay. While traveling to the bay, some nutrients are used up or trapped in sediment, so excess nutrients far upstream have a smaller impact. Alternately, credits for nitrogen could be exchanged for phosphorus credits.

A trading ratio is effectively a discount or exchange rate applied to a credit, making it less valuable. In comparison to nonpoint sources, the discharge from point sources is less variable while being better monitored. The EPA notes that nonpoint sources generate credits that are less certain in measurement, implementation, and performance.[28] Thus, regulators may treat a credit from a nonpoint source as less valuable.[29] The uncertainty that nonpoint source nutrient credits suffer from makes determining the appropriate discount or exchange rate difficult. Are nonpoint source nutrient credits worth half of point source nutrient credits? If the regulator knew how little the nonpoint source nutrient credit was worth, then it would not be uncertain, and no discount would be necessary. In addition, any fixed trading ratio will allow arbitrage between the relatively cheaper credit and the more expensive credit. Even if the ratio was initially set at the correct level, time may shift the costs of nutrient removal to make the ratio no longer true.

Pennsylvania does not permit trading nutrients; therefore, nitrogen cannot be traded for phosphorus. Reductions in excess nutrients are adjusted for where the pollutants enter the stream since excess nutrients introduced downstream have a greater impact on the Chesapeake. The DEP has calculated delivery ratios for all significant point sources[30] and for stream segments.[31] The delivery ratio allows trading between downstream and upstream sources. Without a delivery ratio to adjust for the differential rates of nutrients reaching the bay, the environmental benefits would be unpredictable. All nutrient credits in Pennsylvania are subject to a ten percent reserve, regardless of source.[32] When Pennsylvania began nutrient credit trading, the scheme imposed a twenty percent adjustment on credits generated by nonpoint sources.[33] In 2014, EPA objected to NPDES permits issued by Pennsylvania's DEP that permitted nutrient credit trading, since reductions from farms cannot be measured accurately.[34] To preserve

28. U.S. ENVT'L PROTECTION AGENCY, WATER QUALITY TRADING TOOLKIT FOR PERMIT WRITERS: WATER QUALITY TRADING SCENARIO: POINT SOURCE–NONPOINT SOURCE TRADING 4 (2009).

29. James S. Shortle & Richard D. Horan, *Water Quality Trading*, 14 PA. ST. ENVT'L L. REV. 231, 243 (2006).

30. PA. DEPT. ENVT'L PROTECTION, PHASE 2 WATERSHED IMPLEMENTATION PLAN WASTEWATER SUPPLEMENT 5 (2017).

31. 25 PA. CODE § 96.8 (c) (2010).

32. 25 PA. CODE § 96.8 (a) (2010).

33. 25 PA. CODE § 96.8 (d) (2010).

34. PA. DEPT. ENVTL. PROTECTION, PHASE 2 WATERSHED IMPLEMENTATION PLAN NUTRIENT TRADING SUPPLEMENT 1 (2016). The EPA was not convinced that nutrient credits

Pennsylvania's ability to issue NPDES permits and the nascent nutrient credit trading, DEP adopted a variety of interim measures including a 3:1 trading ratio starting in 2015. Also, DEP has suspended the certification of new nutrient credits, so no new generators can enter the market.[35]

In addition to the problems that affect all nutrient credit schemes, Pennsylvania's system suffers from two self-imposed difficulties. The most significant problem is the timing of the water year. Nutrient credits are good for one water year, which begins on October 1 and ends the following September 30.[36] Pennsylvania set that as the compliance year since most buyers hold NPDES permits and those permits follow the U.S. Geologic Service water year, which coincides with the federal fiscal year. Administrative convenience, however, conflicts with the weather. Although the Atlantic hurricane season runs from June 1 to November 30, there is a sharp peak in late August and early September.[37] Thus, it is possible that the state will see most of its heavy rain at the end of the water year, when it is too late to generate credits or adjust plant operation to reduce the need for credits. On the farm, heavy rain can damage riparian buffers and wash manure into streams. Also, waste water treatment plants are often overwhelmed by heavy rain, especially if the city uses a combined sanitary and storm drain system. Thus, managers release untreated or undertreated water rather than see the waste water treatment plant destroyed by flooding. Of the sixty-four combined systems in the Chesapeake watershed, forty are in Pennsylvania.[38]

There is a second problem with Pennsylvania's approach to nutrient credit trading. Pennsylvania has encouraged the development of credit auctions. The Pennsylvania Infrastructure Investment Authority ("PENNVEST") provides funding to local government, including for waste water treatment. In addition, PENNVEST created a nutrient credit auction, which it calls a clearinghouse. The auctions determine a single price, which applies to all completed trades.[39] Participants in the auction do not deal directly; instead PENNVEST is the counterparty to all buyers and sellers. The auction is structured so that buyers cannot bid on specific credits

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could be calculated from the better management practices without measurement. U.S. ENVTL. PROTECTION AGENCY, PENNSYLVANIA'S TRADING AND OFFSET PROGRAMS REVIEW OBSERVATIONS 9 (2012).

35. PA. DEPT. ENVTL. PROTECTION, PHASE 2 WATERSHED IMPLEMENTATION PLAN NUTRIENT TRADING SUPPLEMENT 1, 7–8 (2016).

36. PA. DEPT. OF ENVTL. PROTECTION, PHASE 2 WATERSHED IMPLEMENTATION PLAN NUTRIENT TRADING SUPPLEMENT 2 (2016).

37. NAT'L OCEANIC AND ATMOSPHERIC ADMIN., THE PEAK OF THE HURRICANE SEASON–WHY NOW? (2016), http://www.noaa.gov/stories/peak-of-hurricane-season-why-now.

38. CHESAPEAKE TMDL, *supra* note 1, at 4-18, Tbl 4-13.

39. PENNVEST NUTRIENT CREDIT CLEARINGHOU SE RULEBOOK: VERSION 8, at 2 (2017).

generated by specific sellers. Instead, every seller receives the same price, regardless of the seller's reliability or method for generating credits.

While single-price auctions are good at determining prices for homogenous goods, nutrient credits are not homogenous. Each credit represents an identical reduction in nutrients, but quality of the credit is highly variable. Some credits are generated in a way that is robust and verifiable. As noted before, waste water treatment plants generate credits of very certain value. Other credits may depend on management practices that are unmonitored, for example manure application. Also, the identity of the seller matters. The buyer wants a solvent seller, especially in the event the seller cannot deliver the credits. A solvent seller can buy replacement credits to deliver to the buyer if she is unable to generate the credits herself.

Municipal water authorities have resources beyond most farmers and other credit generators. Water authorities receive a steady stream of revenue from ratepayers and often borrow money. In contrast, farmers have uncertain revenues and very limited access to credit. Many small farms are already highly leveraged, meaning there is no capacity to absorb a shock like unexpectedly unavailable credits. But, nutrient credit buyers want a solvent seller, so that in the event of breach, the buyer can be made whole, either by buying replacement credits or paying whatever fine is levied for noncompliance.

Single-price auctions prevent buyers from verifying credits and supercharge Gresham's Law. Even if they wanted, buyers cannot select their sellers. Price is the only thing that matters because the auction has been designed to find a single market price and ignore every other aspect of the transaction. Instead of an auction, Pennsylvania should encourage either direct sales or the emergence of brokers. As larger, repeat players, brokers will have more resources and thus be able to substitute for the insolvent farmers. Since brokers do not want to substitute for their defaulting credit generators, brokers will police the reliability of sellers. Also, brokers will have reputations to preserve, so there should be pressure to verify nutrient credits.

III. COVARIANT RISK

The existing literature on nutrient credit trading has not identified covariant risk as a stumbling block. Covariance is a measure of the degree to which two variables move in tandem. Thus, covariant risk is the risk that two events will occur at the same time. Identifying covariant risk is particularly important because covariant risk may be the most significant challenge for nutrient trading and one that better market design cannot overcome. In contrast, other shortcomings in existing nutrient trading schemes can be overcome by improved verification and enforcement,

setting appropriate baselines, and shifting the timing of the water year. Conversely, covariant risk is inescapable and probably dooms nutrient credit trading.

Nutrient credit trading cannot eliminate the risk that all participants suffer from the same event. Rain affects water quality on both sides of the nutrient credit trading. In the Chesapeake watershed, hurricanes (and related tropical storms) bring heavy rain, even very far inland. When rainfall is high, many sellers cannot generate the credits promised. Heavy rainfall increases run-off from farms. More importantly, stream buffers and other management practices are degraded by erosion during heavy rain. Heavy rain will affect all farm sellers similarly, shrinking the number of credits available. Some waste water treatment plants generate credits by removing nutrients in excess of their legal obligation. But in many cities, storm drains combine with sanitary drains, overwhelming the treatment infrastructure.[40] When storm water overwhelms the plant, untreated (or undertreated) water is released and fewer credits are generated. Even though farmers and waste water treatment plants generate nutrient credits in very different ways, both are affected by the same heavy rain. The only nutrient credit generators largely immune to the weather are those who truck poultry manure outside of the watershed.[41]

For essentially the same reasons, nutrient credit buyers need more credits when there is heavy rain. Heavy rain overwhelms all waste water treatment plants, not just those operating beyond the regulatory standard. Thus, a waste water treatment plant that expected to release a certain nutrient concentration would release more nutrients than anticipated. Those excess nutrients must be offset by credits purchased. If the heavy rain came earlier in the water year, it might be possible to meet the regulatory requirement by treating water for the rest of the year to a higher standard. Near the end of the water year, there is no alternative except purchasing nutrient credits.

Heavy rain increases demand while shrinking supply. Thus, the price will increase sharply as buyers compete for the few credits available. Heavy rain will produce price spikes and shortages, making nutrient credit trading less attractive because buyers will not be able to find enough credits and those credits will be extremely expensive. Buying nutrient credits will not be a cost-effective way to meet the requirement, instead it will be an unpredictable and heavy expense. Although municipal water authorities can pass costs onto ratepayers or borrow, neither is attractive since

40. *See, e.g.*, U.S. ENVTL. PROTECTION AGENCY, IMPACTS AND CONTROL OF CSOS AND SSOS (2004).

41. PA. DEPT. ENVTL. PROTECTION, PHASE 2 WATERSHED IMPLEMENTATION PLAN NUTRIENT TRADING SUPPLEMENT 7–8 (2016).

ratepayers are sensitive to price increases and authorities, as public institutions, are politically constrained. Even entirely private water companies operate in a somewhat political environment because the social expectation is that water will be both plentiful and cheap, unlike other markets.

But, the effect on price and quantity is probably less important than the effect on trades already done. Many of the sellers will be unable to deliver the promised credits. Farmers will not be able to generate credits from now destroyed stream buffers. Waste water treatments plants that operated above the standard earlier in the year to generate nutrient credits will see the expected credits disappear as the plant releases nutrient-heavy water during heavy rain. For the same reason that replacement credits are needed, replacement credits may be unavailable. Sellers will find their investment in credit generation devalued or even made worthless, discouraging them from generating credits in the future. Buyers will find that relying on nutrient credit trading was false comfort. Buyers with NPDES permits are not exempt from the permit requirements because the buyer contracted to buy credits that were never delivered.[42] Instead, buyers will find that nutrient credit trading does not help them meet regulatory requirements, at least in years with heavy rain late in the water year.

There are steps that buyers can take to protect themselves from heavy rain and the consequent price spikes and defaults. Buyers could (better) ensure sufficient credits by purchasing more credits than necessary in a typical year. A buyer would have to acquire credits sufficient to satisfy both its greater need for credits and the expected default rate. In a year without heavy rain, many of the credits would expire unused. In dry years, the typical buyer would need fewer credits because its effluent had fewer nutrients. Also, its counterparties would not default. In years with heavy rain, however, the buyer would use every credit, both because its effluent was nutrient-rich and therefore, the buyer needed more credits, but also because many of the sellers it bought credits from would default. If the buyer can recover the sales price from defaulting sellers, the cost of this extra assurance in wet years might not be so great. But, many sellers will be insolvent in wet years. In dry years, however, unused credits would appear to be a very expensive form of assuring that sufficient credits were available.

But, it is unclear whether allowing many credits to expire unused each year is politically feasible. In every dry year, many more credits would be bought than used, which looks like waste. To pay for credits that might

42. U.S. ENVTL. PROTECTION AGENCY, WATER QUALITY TRADING TOOLKIT FOR PERMIT WRITERS: WATER QUALITY TRADING SCENARIO: POINT SOURCE–NONPOINT SOURCE TRADING 29 (2009).

expire unused in most years, the municipal water authority would have to impose higher water rates than if it never bought credits that expired unused. Even if the cost of letting nutrient credits expire in dry years is less than the cost of meeting the regulatory standard through plant improvements (or higher ongoing treatment costs), the apparent waste presents a communication problem. That problem is two-fold because the plant managers must convince both the authority's board and the public that the plant will buy nutrient credits, some of which will expire unused in most years. In a climate hostile to government spending, the cost of letting credits expire unused may be insurmountable. Even if cheaper, unused credits look like waste and oftentimes the perception dominates the reality.

Covariant risk may doom nutrient credit trading. This author is pessimistic, but the architects of nutrient credit schemes can attempt to minimize the effect of covariant risk by doing three things:

First, the end of the water year should not fall during the hurricane season. Instead, the water year should end just before, perhaps in mid-summer. If the water year begins with the hurricane season, both buyers and sellers have the remainder of the year to plan accordingly. While farmers may struggle to generate large numbers of credits between November and the following June, other sellers can generate credits quickly. For example, waste water treatment plants can treat water beyond the permit requirement.

Second, regulating one year at a time may be suboptimal. Since rainfall varies from year to year, a longer regulatory period should reduce the risk of heavy rain and therefore market failure. In a sense, each year's rainfall is a sample from the population which is the climate. Larger samples should be more regular than smaller samples. A longer period than one year, however, does not protect against the risk that the heavy rain will come at the end of the period. Heavy rain at the end of a water decade presents the same problems as heavy rain at the end of the water year. Additionally, a longer period would allow water quality to suffer in any given year, so long as water quality over the period met the standard. Many biological processes depend on water quality at every moment, not just on average. Fish need water with dissolved oxygen continuously, not just on average. Since the climate is not stable, a long-term trend of increasing rain, and heavy rain, in particular, could present recurrent end of period problems. On average, the end of every period will appear wetter than expected because the long-term trend is towards heavy rain.[43] Therefore, a longer regulatory period may not cure the problem.

43. U.S. GLOBAL CHANGE RESEARCH PROGRAM, GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES 44 (2014).

Lastly, letting credits expire unused presents a communication problem, which becomes a political problem. To solve the problem of perception, the architects of nutrient trading schemes may want to add another layer of deception. The unused credits are insurance, but it might be more palatable if a market intermediary held the credits that expire unused. Insurance is prudent and thus an insurance policy is not waste. While paying an insurance premium is equivalent to buying credits that will expire unused, buyers may find it more palatable. Of course, the market regulator will need to oversee the insurer for the same reasons that government regulates more traditional types of insurance. Setting aside insufficient assets (buying too few credits) would provide a competitive advantage and thus reckless insurers would come to dominate the market, at least until the wet year when the insurance would fail. There are costs associated with market intermediaries, which will ultimately be borne by buyers, but the increased costs may be less than the alternative, which is avoiding nutrient credit trading because of the communication problem.

IV. CONCLUSION

Nutrient credit trading suffers from several shortcomings already identified in the literature, including the difficulty of verification, regulatory arbitrage, and the inherent difficulties in setting baselines and trading ratios. In Pennsylvania, nutrient credit trading suffers from several specific difficulties, including the mistiming of the regulatory year and an emphasis on auctions. None of the existing literature, however, identifies covariant risk, which this Article argues may present an insurmountable obstacle to nutrient credit trading.

In the eastern United States, our weather "sendeth rain on the just and on the unjust."[44] Heavy rain prevents sellers from generating credits. The same rain means that buyers need more credits. The market for nutrient credits will see unstable prices, with predictable peaks in price (with potential shortages) at unpredictable times. The result is that nutrient credit trading may be impossible because unstable prices will make planning by both buyers and sellers impossible. Covariant risk may present insurmountable problems for nutrient credit trading, suggesting that direct regulation of agriculture may be necessary.

44. *Matthew* 5:45 (King James).