

**COMPARATIVE INSTITUTIONAL AND POLICY ANALYSIS OF
NONPOINT SOURCE AGRICULTURAL
NUTRIENT POLLUTION IN THE CHESAPEAKE BAY**

by

Jennifer M. Egan

A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Water Science and Policy

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NUTRIENT POLLUTION IN THE CHESAPEAKE BAY**

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ABSTRACT

Reducing excess nitrogen and phosphorous (nutrient) runoff into ground and surface waters is a global concern (Jacobs, 2013). More than two decades of effort in the United States Chesapeake Bay region to reduce nutrient excess has seen slow progress (U.S. EPA, 2010). The externality of nutrient excess has spurred environmental groups to seek rights they view as unallocated in resolution processes. This dissertation presents several ideas regarding nutrient externality. The second chapter argues that the judicial process is poorly positioned to resolve this conflict—relative to other resolution processes—and other processes would be more likely for environmental groups to achieve their goal of improving environmental quality. The third chapter addresses the design and implementation of effective policy for nutrient reduction from nonpoint source agriculture. Nutrient management planning and nutrient trading requirements are comparatively analyzed in Maryland, Pennsylvania, and Virginia to determine factors in policy design that affect policy outputs. The results indicate that an existing institutional structure utilizing incentive-based nutrient management planning may be more compatible with nutrient trading policies and in turn may reduce the cost of monitoring. Although monitoring cost increase with nutrient trading, the existing policy design in Virginia may provide capacity to lower monitoring cost. The fourth chapter analyzes payment for environmental services (PES) and nutrient trading with a novel approach. A nutrient index combines PES for nitrogen and phosphorous reduction and a sensitivity analysis, into a single payment to elicit potential costs of supply in the nutrient market. This nutrient index is the first of

its kind to distinguish payments made for multiple environmental services and to explore the impact on policy effectiveness with overlapping nutrient reduction policies. PES and nutrient trading policies pay for the same service yet PES, as demonstrated in the results of this study, has potential to increase prices of nutrient credits (establish a price floor) or collapse the nutrient trading market altogether. In addition, the existence of the trading market has potential to reduce the effectiveness of existing PES, which already suffers from ineffective payment for nutrient services.

Chapter 1

INTRODUCTION

The program of Water Science and Policy was designed to train students to confront problems society will face as the future distribution, quantity, and quality of water changes with population growth, agriculture, and industry needs. This dissertation addresses policy challenges faced in the agricultural sector where water is integral to food production, but includes an externality of nonpoint source nitrogen and phosphorous (nutrient) enrichment to local and regional waters. In addition to conflict resolution institutions that address nonpoint source nutrient excess, such as the legislative, judicial, and regulatory processes, these chapters compare monitoring requirements and policy designs in Maryland, Pennsylvania, and Virginia, and economic implications of contemporaneous use of incentive-based instruments: nutrient trading and payment for environmental services (PES). These instruments have been developed to provide economic incentive for nutrient reduction and to bridge the gap left by the exemption of agricultural nonpoint sources from federal regulation in the Clean Water Act.

Excess nutrient runoff into ground and surface waters is a global concern (Jacobs, 2013). More than two decades of effort in the United States (U.S.) Chesapeake Bay region to reduce nutrient excess has seen slow progress (U.S. EPA, 2010). After decades of algal blooms in the Great Lakes, a major toxic bloom in 2014, caused by excess nonpoint nutrients, impacted drinking water supply (Anderson, 2015). Policies (such as nutrient management planning) were quickly enacted in 2014

to begin reducing the nutrients to the lakes. However, science indicates that the policy solutions implemented today will take decades to improve water quality and there are many factors that affect successful nutrient policies such as scientific knowledge of nutrient cycling and ability to monitor practices to reduce nutrients (Sharpley et al., 2013; Meals et al., 2010; Zaring, 1996; Albright, 2015). In addition, recent estimates suggest that meeting the Chesapeake Bay total maximum daily load for nutrients (Bay TMDL) may cost \$3.5 – \$5.0 billion for agriculture alone (Kaufman et al., 2014). The global concerns for nutrient reduction stem not only from protecting human health and well-being and addressing the complexities of impacts to ecological systems, but also the cost of policies designed to reach those goals (Wainger, 2012).

Design and implementation of efficient policy for nutrient reduction from nonpoint source agriculture poses some of the most difficult challenges. The nature of agricultural nonpoint sources (Ribaud and Caswell, 1999) makes monitoring of excess nutrient discharges costly (National Research Council, 2011). This cost is potentially one of several reasons nonpoint source agricultural activities are excluded from the definition of point sources that discharge nutrients and are exempt from the Clean Water Act (Kaufman et al., 2014; Wainger, 2012; U.S.C 33 § 1362; Gould, 1989; Williams, 2002). In the U.S., nutrient reduction policies for agricultural nonpoint sources are predominantly flexible and incentive-based (Dowd et al., 2008; Shortle et al., 2012; Ribaud et al., 2014), but they have limited success (Williams, 2002; Ribaud et al., 2014). Because of the limited success, and the impending 2025 TMDL (U.S. EPA, 2010), many states surrounding the Chesapeake Bay have instituted new policies, such as nutrient trading, to encourage the agricultural nonpoint source sector participation in activities that help reduce excess nutrients. Excess

nutrient runoff from the surface (during precipitation events) from agricultural fields is considered a leading nonpoint source of impairment in the Chesapeake Bay but is specifically exempted by definition in the Clean Water Act as “agricultural stormwater” or “irrigation return flows” if the field is not part of a concentrated animal operation (CWA § 1362 (14); Beegle, 2013, U.S. EPA, 2006). Groundwater discharges of nutrients are also not regulated in the CWA.

Voluntary measures of nutrient reduction by agriculture - the largest nonpoint source of nutrients in the Chesapeake Bay - have been deemed ineffective to reduce significant amounts of nutrients; as such, policy makers have turned to market and incentive based policies to encourage adoption of nutrient reduction practices (Ribaud et al., 2014; Shortle and Horan, 2013). Further, the ineffectiveness of current policies and lack of progress has led to conflicts and litigation over the resource at stake in the Chesapeake Bay (the Bay) region. The resource at stake is not the water quality in the Bay but extends to the use of land in the watershed. Environmental groups have begun to pursue perceived unallocated rights to clean water through filing lawsuits against agricultural producers. However, as the second chapter argues, litigation is not necessarily the best pathway for securing disputed rights, and legislative resolution processes hold better outcomes for conflict resolution as demonstrated by case study of *Waterkeeper v. Hudson*. The third chapter involves analysis of nutrient management planning and nutrient trading. Market-based policies, such as trading, are viewed superior to regulation, the assumption being, that the market will provide economic efficiency where high cost polluters find low cost alternatives for abatement through trade. However, as the third chapter argues, current institutional structures and transaction costs in the Bay states prohibit widespread

effectiveness of trading as a policy. Finally, PES, and nutrient trading are proposed to incentivize agricultural management practices that would otherwise not be implemented without payment (such as cover crops) and to deliver desirable environmental services from non-regulated entities. The fourth chapter shows the implications of policy interaction utilizing two incentive-based policies that have the same goal of reducing nutrients from agricultural producers. The results indicate that the interaction of an existing policy with a new policy may result in less-than-expected effectiveness for both policies.

Chapter 2

WATER QUALITY CONFLICT RESOLUTION AND AGRICULTURAL DISCHARGES: LESSONS FROM WATERKEEPER V. HUDSON

(Chapter 2 was originally published in its entirety: Jennifer M. Egan and Joshua M. Duke, *Water Quality Conflict Resolution and Agricultural Discharges: Lessons from Waterkeeper v. Hudson*, 39 Wm. & Mary Env'tl. L. & Pol'y Rev. 533 (2015), <http://scholarship.law.wm.edu/wmelpr/vol39/iss3/2>. Copyright permission for published material from William and Mary Environmental Law and Policy review, see Appendix C. **“Author Maintains Non-Exclusive Right to Reproduce. Author maintains the copyright to the Article and the non-exclusive right to reproduce and authorize others to reproduce and distribute the Article, in whole or in part, in anthologies, textbooks, journals, or any other published format, for profit or not for profit, with appropriate attribution to both the Author and to ELPR.”**)

The *Waterkeeper v. Hudson* (*Waterkeeper Alliance, Inc. v. Alan & Kristin Hudson*, 2012) case garnered intense public scrutiny (Urbina, 2010) in part for its precedent-setting potential, whereby the poultry industry could assume liability for agricultural pollution associated with litter and its land application (Fahrenthold, 2010). At first glance, the case outcome simply appeared that industrial agriculture prevailed against attack from environmental groups. However, when comparatively analyzed in terms of institutions and societal goals, the *Hudson* case reveals that the lesson is far more complex. More importantly, the comparative institutional analysis leads directly to policy prescriptions that can improve water-land nexus conflict resolution. This article argues that the judicial process is poorly positioned to resolve this conflict—relative to other resolution processes—and other processes would be

more likely for environmental groups to achieve their goal of improving environmental quality. The judicial process often balances the economic efficiency of competing uses (which, arguably, tip in favor of the agricultural operator targeted by the case), but it is poorly positioned to process this conflict because of unallocated rights remaining in the underlying conflict of interests. The judiciary is poorly positioned to resolve this conflict because, currently, legislatures and agencies (quasi-judicial resolution) offer little guidance on the allocation of rights and duties, involving agricultural discharges. Quasi-judicial processes are typically better positioned to resolve highly complex scientific natural resource conflicts (Duke and Csoboth, 2003) and to assign previously unallocated rights, using legislative rules as guidance, when ecological interdependencies require systematic processing of scientific evidence. However, there are so many agricultural discharge conflicts, that future dispute resolution processes will undoubtedly decide more cases in the near future.

This article presents a comparative institutional analysis of an increasingly important type of environmental conflict—the agricultural-waste-discharge and water-land-nexus conflict—using the recent citizen suit *Waterkeeper v. Hudson* (hereafter ‘Hudson’ 2012) as a case study. The objective is to assess the resource allocation efficiency and procedural fairness of the dispute processing in *Hudson* (2012). The *Hudson* (2012) setting involves substantial scientific complexity, including ecological interdependencies, unobservable and observable land management decisions, pollutant transport, in-stream removal, and the problem of multiple and diverse sources of water quality pollution. Although the Hudson farm does fall under a regulated point source category in a state legislative definition, not all agricultural practices on the property

are regulated. *Hudson* (2012) and other cases are demanding clearer definition of rights allocated and duties assigned in the water-land nexus conflict.¹

One part of the argument is that the *Hudson* case is important, but not for the reasons articulated in popular press coverage (Waterkeeper, 2012; Nathanson and Chung, 2013; Wheeler, 2012; Kobell, 2012). The case itself—as opposed to the broader conflict or agricultural nutrient pollution—is at best an anomaly holding little precedential insight. At worst the case led to a judicial opinion that took a severe tone and that led some to see the case as an unredeemed waste of time and resources. (Olson, 2012). The comparative institutional analysis of the *Hudson* conflict shows that, although all resolution processes are imperfect (Komesar, 1994) the judicial process is not situated to resolve the conflict well and the legislative process is the best positioned to achieve societal goals of fairness and efficiency. Moreover, two factors affect a broader analysis of conflicts between agricultural discharges and environmental interests going into the future. First, some key rights to the land-water nexus have been allocated, and, as these are fully formalized, there are progressively

¹ Concerned Area Residents for the Environment v. Southview Farm (1994) and *Alt v. EPA* (2013) provide examples. In *Alt* the court clarified a CAFO is not an “industrial” operation and that stormwater in a farm yard is agricultural stormwater exempt from permit regulation. The key difference in the *Alt* and *CARE* cases hinged on precipitation, in *CARE* the discharge was observed in absence of precipitation. These cases show an attempt to expand regulatory authority over agricultural discharges through stormwater criteria or industrial classification. These cases are important in that they continue to define Congressional intent. Statute is clear and discharges associated with CAFOs are not allowed outside of the national pollution discharge elimination system (NPDES) permit and discharge associated with precipitation is exempt.

fewer rights to allocate. Second, over time, human values of the environment change with increasing scarcity. That is, as awareness of land use intensity and external effects are more prevalent, unallocated rights to low intensity uses become more valuable for environmental interests (Centner, 2010). This implies that recent reliance on quasi-judicial rules to restrict agricultural discharges, rather than legislative action, will lead to more conflicts and less clarity. New legislative guidance is needed on what uses of water resources constitute property rights. In other words, the Clean Water Act has very little to say about nonpoint sources, and this silence will continue to propel conflicts like *Hudson* into courts. Finally, this analysis shows the citizen suit provision in the Clean Water Act (Federal Water Pollution Control Act, 33 U.S.C. § 1365(a)(1) (1994) did not achieve water protection goals in this case, and the parties that bring similar suits in the future are not well positioned to succeed in the judicial resolution process.

There are five sections of this chapter. Section I contains the background of the water-land nexus conflict on the Eastern Shore of Maryland, which led to the *Hudson* case. The historical evidence reveals an increasing scarcity of resources, through enhanced competition among intensive developed and agricultural land uses as well as enhanced calls for environmental protection. Section I concludes that these forces have, inevitability and foreseeably, increased conflict because of the corresponding decrease in capacity of the water-land nexus to absorb, store, and cycle nutrients and bacteria from intensive uses. Section II outlines the comparative institutional analysis method adapted from Komesar (1994) and extended by Duke (Duke, 2004) to assess conflict resolution performance in specific environmental conflicts. Section III explains the data from the *Hudson* case study, which are used to

inform the comparative institutional analysis. These data include systematic evidence on each interaction where disputants competed for control over the natural resource and conditional rights were allocated. Section IV applies the comparative institutional analysis to the data. Section V draws implications and conclusions for policy and law.

The Water Land Nexus Background

Pocomoke Watershed and Human Impacts

For thousands of years prior to the 1600s, the area in southern Delaware and southeastern Maryland was covered in dense vegetation with solid stands of bald cypress and Atlantic white cedar (Sipple, 1994; Holden, nd). Tribes of the Algonquin Nation including the Pocomoke, Nanticoke, and Nassawattox occupied the riverbanks and were presumably sustained in part by bountiful fish and bivalve populations such as oysters (Miller, nd).² Beginning in the early 1600s, the native tribes relocated as European colonists moved into the area (Holden, nd).

As the European colonists populated the Pocomoke watershed, the use of land and water began to intensify. Oysters were an important food source, but the stock was thought to decline for the first time since human habitation between 1640 and 1690 (Miller, nd). The early settlers relied on food from the waterways as well as food grown on land and, from 1700 to 1900, Pocomoke watershed land uses included tobacco and other farms, bog iron mining, and timber felling (Sipple, 1994 pg. 3). Timber production was essential to the early settlers in the late 1700s and early 1800s

² One translation of Chesapeake in the Algonquin language is “Great Shellfish Bay” (Miller, nd). In the early 1600s, English settlers of the Chesapeake Bay recorded banks of oysters that were so large ships had to take care to avoid them.

as swamp cedar was used for “shipbuilding, shingles, siding on homes, water tanks and coffins” (Holden, nd). Shipping of tobacco and lumber encouraged the growth of towns and landings (Holden, nd). By 1850 many of the large trees were gone (Sipple, 1994, pg. 4) and by 1930 the swamp forest had been “completely timbered” (Holden, nd).

Timber clearing affects water quality (Ensign and Mallin, 2001) as well as over harvesting filter feeders such as oysters. Filter feeders obtain food through filtering water and in the process remove (or sequester) nutrients and sediment (Higgins, Stephenson, and Brown, 2011). In the years following the Civil War, around five million bushels of oysters were harvested in Maryland and 20 million bushels harvested each year at the peak in the mid-1880s (Miller, nd). In contrast, by 1920, annual takes were from three to five million oysters in the entire Chesapeake Bay, and populations continued decline into the twentieth century (Miller, nd). Not only were oysters a food source but were important to the ecosystem and water quality of the Chesapeake Bay (Holden, nd). Recent research indicates that oysters have substantial filtration capacity and are able to remove large quantities of nutrients, organic material, and sediment, and oyster stock decline would have had an early influence on the water quality in the Chesapeake Bay (Newell et al., 2003).

Maryland’s Agricultural History

Maryland’s agriculture history was tied to population migration, wars, and expanding transportation. At Maryland’s statehood, tobacco farming had depleted soil fertility in certain areas, but crop and animal agriculture continued as a regional food supply for the American Revolution (Agriculture in Worcester County). Portions of the population migrated to Baltimore, which was a major port that provided ship

building and industrial employment (The Eastern Shore Guide.) During the War of 1812 and the Civil War, food supply was again in high demand and Maryland's agrarian Eastern Shore supported the soldiers with dairy, fruit, and vegetables (Agriculture in Worcester County). Livestock production increased after the War of 1812 but declined due to disease after the Civil war (Agriculture in Worcester County). After the Civil War, agriculture on the Eastern Shore intensified from 3,000 farms in 1890 to 5,000 farms in 1925 as shipping and rail lines providing access to markets in Philadelphia and the region (Barnes, 2006). The farms were greater in number but smaller in acreage signifying an increase in intensive farming techniques. (Barnes, 2006). Agriculture was the dominant industry in Maryland until the Great Depression when farming decreased, but production efficiency gains in farming practices maintained agriculture as a primary industry on the Eastern Shore into the mid-1900s (Barnes, 2006; Agriculture in Worcester County).

High Intensity Poultry Farming (Animal Feed Operations, AFOs)

Agricultural innovations in the mid-1900s, favorable natural resource conditions, and new markets eventually led to the transformation of southern Delaware, eastern Maryland and Virginia (Delmarva) to high intensity poultry farming (Adler and Lawler, 2012). Unlike other livestock farming that began industrialized production in the early 1900s, chickens were mainly used for egg production and kept in smaller numbers (Adler and Lawler, 2012). Some attribute large-scale poultry farming to a hatchery shipping error in 1923 when an Ocean View, Delaware, housewife mistakenly received 500 chicks instead of 50 chicks (Plowman, nd). However, bird mortality was an issue with early confined poultry operations (Plowman, nd). Innovations such as antibiotic and vitamin fortified feed (Adler and

Lawler, 2012) and new bird breeds (Thayer et. al., 2012) allowed birds to be confined and grown in large numbers with lower mortality. Birds went from 16-week growth period to reach 2.2 pounds in 1920 to 5 pounds in seven weeks by 2009 (Hribar, 2013).

Delmarva offered a favorable set of climatic geologic and demographic characteristics for poultry farming as well (Plowman, nd). The temperate climate of the region reduced heating costs of enclosures, and the Coastal Plain's sandy soils allowed drainage and reduced diseases carried by water (Plowman, nd). Additional advantages included knowledgeable egg farmers, cheap labor from the failing timber industry, and close proximity to shipping and rail made getting the poultry to market faster (Plowman, nd). By the mid-1950s, supermarkets and fast food chains such as Kentucky Fried Chicken demanded getting chicken to market faster and in higher numbers (Thayer, et al., nd). Increased population, faster processing, and vertical integration (from egg to bird to table by one company) (Plowman, nd) led to intensified, concentrated animal production such as the Hudson's.

Animal feed operations concentrate animals to increase efficiency of supply. The poultry industry uses vertical integration where one company owns most (if not all) of the steps in the production process from egg to market (Sams, 2001). Some companies expand to own grain and feed supply or have stakes in breeding and hatchery portions of the market (Sams, 2001, pg. 2). The purpose of vertical integration in poultry, as with other industry processes, is to create uniformity in goals, production, and oversight and ultimately reduce costs of production (Sams, 2001). Integrators such as Purdue Farms, Inc., contract with family owned business to grow

the birds that are received from the integrator owned hatchery, and the integrator owns most, if not all other aspects of the production process (Vertical Integration).

Water Quality Impacts of AFOs

Environmental effects from concentrated livestock and poultry have been reported for decades. Animal production discharges include elevated concentration of hormones, heavy metals, antimicrobials, detergents, and disinfectants in the surrounding environment (Hribar, 2013). Concentration of chickens also increases manure (and subsequently litter) produced per acre. This is more usefully seen scientifically as a watershed nutrient-balance problem, rather than as an ethical problem of blaming poultry producers for pollution. Poultry concentration involves a massive relocation of nutrients in the form of corn, soybeans, and other feed from vast croplands (which are often located outside the Chesapeake Bay Watershed) to a relatively concentrated livestock production area. Chickens are extremely efficient (relative to other meat producers such as cattle and hogs) in producing meat from feed, but some feed becomes waste (Sams, 2001, pg. 275).

Poultry litter is manure that is mixed with wood shavings or sawdust, is collected from the floor of poultry houses, and is typically composted then spread on crop fields for fertilizer. The litter is composted for several weeks before it is applied to remove bacteria and reduce nutrient concentration (Hochmuth et al., 2009; Mahimairaja et al., 1996; Ihnat and Fernandes, 1996). After composting the litter is spread on agricultural fields where it is a valuable nutrient input for nearby crop production (Hochmuth et al., 2009; Mahimairaja et al., 1996; Ihnat and Fernandes, 1996). However, a nutrient imbalance can arise because the feed nutrients consumed on the Eastern Shore are derived from extensive croplands that are outside the region.

Ideally, the nutrients (in the litter) would be returned as fertilizer to grow crops in the mid-west. Removal of nutrients from the Eastern Shore watersheds as finished poultry products is insufficient to return, fully, the nutrient balance of the watershed (Sims et al., 1998; Sims, 1974).

It is estimated that Delmarva had 50,000 chickens in 1925 and that number increased to 602 million by 1998 (Sims et al., 1998). The sheer number of poultry grown and the use of fortified feed increased the use of feed from outside of the region, reduced the amount of feed grown within the region, which also limited the regional use of manure (Hribar, 2013, pg. 2). The net result of these forces is an excess of manure in Delmarva (Sharpley, et al., 1998; Ward and Ritter, 2003). Excess manure is managed in various ways such as ground application beyond crop-uptake need as a crop risk management strategy, trucking manure off-site or outside the watershed, and pelletization (Sharpley, et al., 1998; Ward and Ritter, 2003). Best management practices (BMPs) such as vegetative buffers, litter management, and precipitation runoff control, can be used at the poultry facility or on fields where manure is spread to intercept nutrients and reduce nutrient concentration leaving the field (Lavergne et al., 2011). However, even with the manure management strategies, excess nutrients are still problematic for waterways in areas where animal feed operations (AFOs) are present (Sims 1998, pg. 289; Hribar, 2013 pg. 3).

Watersheds with many AFOs (or high agricultural use in general) may experience water quality impairments such as decreased oxygen for aquatic species, toxic microorganisms, or bacteria concentrations that exceed standards due to high nutrient content and bacteria in manure or litter (Hribar, 2013, pg. 2; Boesch et al., 2001; Howarth, et al., 2011). Eutrophication occurs when nutrients in excess of

assimilative capacity of the water body provide fuel for primary production in the water column (mostly algae) (Hribar, 2013, pg. 4-5). When the algae die, dissolved oxygen is consumed from the water column. Fish, along with other aquatic organisms die because they rely on dissolved oxygen to survive (Boesch et al., 2001).

Submerged aquatic vegetation (SAV) provide habitat and also produce oxygen. As the algae grow, light penetration through the water column is reduced, which reduces SAV growth and subsequently reduces habitat and oxygen production (Boesch et al., 2001). The decrease in SAV and dissolved oxygen both increase fish and other aquatic organism mortality (Boesch et al., 2001). Nutrient excess can also encourage growth of toxic cyanobacteria and dinoflagellates (*Pfiesteria*) and increase drinking water filtration requirements (Burkholder and Glasgow, 2001).³ *Pfiesteria* is a toxic microorganism related to high phosphorous concentrations that invades fish and creates a potent neurotoxin that affects humans who have contact with the fish (Burkholder and Glasgow, 2001). Recently, the toxic cyanobacteria bloom in Lake Erie near Toledo, Ohio highlighted the extensive, negative impact of excess nutrients (Zimmer, 2014). In addition, areas with AFOs can have bacteria levels that exceed primary contact recreation standards necessitating beach closures (Wood, 2013).

The Comparative Institutional Analysis Method

Institutional analyses are conducted in various ways, and differ in the unit of analysis and what constitutes participation by important actors (Ostrom, 2007; Junker, Buchecker, and Müller-Böker, 2007; Luyet et al., 2012). Institutional analysis

³ Many toxic *Pfiesteria* outbreaks have plagued the Albemarle-Pamlico Estuarine System, including events both before and after the 1997 outbreaks in Chesapeake Bay.

nevertheless provides a framework for researchers to understand the “policy process by outlining a systematic approach for analyzing institutions that govern action and outcomes within collective action arrangements” (Mellouli, 2014, pg 6; Ostrom, 2007). Carr et al. compare three methods for evaluating public and stakeholder participatory action in the European Water Framework Directive and the Clean Water Act (2012). Hardy and Koontz identify de-centralized institutions as local decision making bodies that also necessitate involvement of the local residents and stakeholders (2009). Hardy and Koontz compare formal (laws and regulations) and informal (community exchange) institutional rules and the actions that result from government, citizen centered, and mixed (government and citizen) participation to understand decision-making partnerships (2009). These two approaches help convey the variety of methods and approaches in institutional analysis, but this article will follow the widely applied and cited method from Komesar (Cole, 2013). Komesar’s method uses a participation-centered approach to examine the performance of different resolution processes relative to important social goals, such as protection of property or promoting safety (Komesar, 1994, pg. 4). Komesar and Duke and Csoboth focus on the goals of resource allocation efficiency and procedural fairness (Duke and Csoboth, 2003, pg. 541,551).

Komesar’s comparative institutional analysis (CIA) is an analysis of goal and institutional choices (1994, pg. 5). Komesar stresses that analyzing one institution alone will “tell us nothing about outcomes” (1994, pg. 4-5). The importance of comparing market, judicial, and political institutions helps examine what institutional choice best carries out society’s goals of efficiency, justice, and fairness (Komesar, 1994, pg. 5). Institutional participation in Komesar includes consumers, producers,

voters, lobbyists, and litigants (1994, pg. 7). Accounting for the participating group's actions and involvement determine how well the institutions function; and, additionally, the adjudicative and political process can be assessed in similar terms to the market process (1994, pg. 7). Komesar's framework includes analysis of the costs and benefits of participation in the market, judicial, and political institutions (1994, pg. 8.) A recent review showed that Komesar's approach has made a significant, extensive impact on legal analysis (Schaffer, 2012).

Duke adapted Komesar's approach to form a comparative resolution process that analyzes institutional performance in specific environmental conflicts, using the social goals of Coasean efficiency and fairness (Coase, 1960; Duke 2004, pg.234, 248). Analysis of performance focuses on seven types of institutions (really, conflict resolution processes) that process disputes involving environmental quality (Duke and Csoboth 2003, pg. 550). Duke's method extends Komesar's approach to focus on micro-level data and dovetails this with an extended version of John R. Commons's (1931) framing of market, managerial, and rationing transactions with the concept of environmental (or land-use) transactions (Duke 2004, pg. 244-245). The seven general processes for comparison in conflict resolution are market, quasi-market, legislative, quasi-judicial, judicial, moral suasion, and alternative dispute resolution (Duke and Csoboth 2003, pg. 550). Institutions, in Duke's analysis, are rules or laws that guide the functioning of the resolution processes (Duke 2004, pg. 229-30). In application, the *Red Wolf Conflict (Red Wolf)*, compares conflict outcomes of the quasi-judicial and judicial process with the goals of procedural fairness and an operationalized substantive efficiency concept derived from Coase (Duke and Csoboth, 2003, pg. 542; Coase, 1960, pg. 44). The *Red Wolf* analysis concluded that

quasi-judicial resolution processes have a superior capacity to resolve conflicts with increased scientific complexity (Duke and Csoboth, 2003, pg. 542). Similar to *Red Wolf*, the analysis of the *Waterkeeper v. Hudson* conflict herein examines the resolution processing between landowners and environmental private parties. The judicial, quasi-judicial, legislative, and moral suasion resolution processes are compared using the metrics of procedural fairness and Coasean substantive efficiency (Coase, 1960, pg. 44).

Water Quality Conflict Data

Citizen Suit Provision

The citizen suit provision established statutory standing for environmental groups to file suit against anyone "who is alleged to be in violation of...an effluent standard or limitation under this chapter" (Federal Water Pollution Control Act, 33 U.S.C. § 1365(a) (1) (1994)). The legislative process, through the Clean Water Act, began to allocate rights to parties in land-water nexus conflicts; however, this analysis will show that the rights allocation is incomplete in agriculture discharge problems and it is the unallocated rights that create conflict between parties. Precedent is unclear in citizen suits, but it is clear Congress envisioned a limited reach, where citizen suits do not supplant but supplement state and federal enforcement actions.⁴ The U.S. Environmental Protection Agency (EPA) has renewed focus on meeting

⁴ It has been argued citizen suits that are allowed to proceed after a state consent decree is agreed upon "muddy the issues" of the regulatory and enforcement process (Campbell, 2000). Campbell argued further, consideration of awarding court fees to the plaintiff citizens that spurred the settlement would recognize the intent of the statute provision (2000).

goals to improve water quality as demonstrated by the 2009 Executive Order (Executive Order 13508, 2009) and the 2010 Chesapeake Bay total maximum daily load (the Bay-wide TMDL) (U.S. Environmental Protection Agency, Chesapeake Bay TMDL). Recent litigation suggests pressure is building for the EPA to regulate nonpoint sources as well as strengthen enforcement of agricultural point sources.⁵

Several recent cases brought agricultural nonpoint pollution into judicial review. The United States Court of Appeals for the Second Circuit in *Concerned Area Residents for the Environment v. Southview Farm* considered a New York dairy farm's manure spreading operations, typically considered a nonpoint source activity, a point source (*CARE*, 1994). The court decided the operation was in association with a regulated concentrated animal feed operation (CAFO) and therefore was regulated under the CWA (*CARE*, 1994). In *Pronsolino v. Nastri* the Ninth Circuit Appellate Court upheld the long-standing CWA interpretation that states must identify waters impaired solely by nonpoint sources and establish total maximum daily loads (TMDL)

⁵ The Clean Water Act of 1977, 33 U.S.C. §§ 1251 et seq. provides that, absent a permit and subject to certain limitations, the discharge of any pollutant by any person shall be unlawful. 33 U.S.C.S. § 1311(a). A pollutant includes solid waste, sewage, biological materials, and agricultural waste discharged into water (33 U.S.C.S. § 1362(6)). A "discharge" is "any addition of any pollutant to navigable waters from any point source" (33 U.S.C.S. § 1362(12)). The term "point source" includes "any discernible, confined and discrete conveyance, including but not limited to any concentrated animal feeding operation. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture (33 U.S.C.S. § 1362(14)). Under the Clean Water Act (§ 402, 33 U.S.C.S. § 1342(a)) industrial, municipal, and concentrated animal feed operations ("CAFO") point sources are regulated through the issuance of national pollution elimination discharge (NPDES) permits (§ 1342). Although Sections 208 and 303 direct states to identify and control nonpoint source pollution, under Sections 402 and 404 agricultural discharges (stormwater), not associated with a CAFO, are specifically exempt from regulation (33 U.S.C.S. § 1362(14)).

for those waters (*Pronsolino v. Nastri*, 2002). In 2010, a landmark decision was made unanimously in the Ninth Circuit Court of Appeals against forestry, lumber, and paper products associations (*Northwest Environmental Defense Center v. Brown (NEDC v. Brown)*, 2007). The Ninth Circuit held in *NEDC v. Brown* that polluted runoff from logging roads—again typically considered a nonpoint source and also exempt from regulation in the CWA—that collects in ditches is not exempt under the CWA (2011). However, in March 2013 the U.S. Supreme Court reversed and found that national pollution discharge elimination system (NPDES) permits were not required (*Decker v. Northwest Environmental Defense Center (Decker v. NEDC)*, 2013). Justice Scalia, in dissent, stated that the majority opinion failed to give adequate clarity to logging as an industrial activity (industrial activities are regulated under NPDES) (*Decker v. NEDC*, 2013). This case is important because it is one of several that strongly argue polluted runoff from diffuse sources which collects in pipes, ditches, and swales can be considered a point source. Like the claim in *NEDC v. Brown*, plaintiffs in the 2011 Maryland District case *Waterkeeper Alliance Inc. v. Hudson et al.* alleged Hudson was discharging illegally without an NPDES permit (*Hudson*, 2012). The District Court of Maryland dismissed the plaintiffs’ claim, but the implications of the judgment are important to consider in citizen suit efficiency, fairness, and nonpoint source conflict resolution.

Hudson Case Study

Hudson is examined as a case study of the transactions that occur in the conflict resolution process to allocate rights. The timeline of the case is summarized below. The Hudson farm is located on the Eastern Shore of Maryland approximately 3.5 miles from the Pocomoke River. The Hudson’s operation is family owned and

contains field crops, poultry, and beef cattle (Hudson, 2012, pg. 1).⁶ In October 2009, the Waterkeeper Alliance and the Assateague Coastkeeper (herein, the environmental party) flew over the Hudson farm (herein, poultry party) and photographed what was assumed to be a pile of poultry litter or manure near a ditch. The environmental party sampled water in the Franklin Branch of the Pocomoke River in October through December 2009, found elevated levels of nitrogen, phosphorous, and bacteria (pollution), then held a press conference and issued a press release (Hudson, 2012, pg. 4-5). In anticipation that the pile was manure or litter and the poultry area of the farm was illegally discharging pollution from poultry litter, the environmental party filed notice of intent to sue for Clean Water Act violation in December 2009. The environmental party continued to sample the water in the Franklin Branch and find elevated pollution levels and issued another press release in February 2010 stating that the pile was “uncovered manure” next to a drainage ditch (Hudson, 2012, pg. 4).⁷

State of Maryland employees from three agencies including the Department of Environment (MDE), Soil Conservation District, and Department of Agriculture visited the Hudson farm for a regulatory inspection in December 2009. This visit was in response to the intent to sue and the state employees discovered that the pile, which the environmental party saw on their flight, was Class A bio-solids from the Ocean

⁶ Purdue Farms, Inc. a poultry integrator that purchased Cornish hens from the Hudson farm was initially named in the lawsuit, and subsequently dismissed under motion to dismiss (Hudson, 2012, pg. 1).

⁷ The environmental party sampled the Franklin Branch through April 2010 and found elevated levels of nitrogen (Total Kjeldahl Nitrogen), Phosphorous (P), Escherichia Coli (E. Coli, bacteria), and fecal coliforms (FC) (Hudson, 2012, pg. 4 note 6).

City Wastewater Treatment plant and not poultry litter (Hudson, 2012, pg. 11).⁸ During the December 2009 inspection, the MDE issued a \$4,000 fine to Hudson for “improper storage,” which an administrative judge later declined to impose. Maryland Department of Environment visited the Hudson farm again on January 26, 2010, and sampled the ditches on the farm. No fines were issued at this visit; however, one of the MDE samples revealed significantly elevated pollution levels in the ditch close to where the environmental party water samples were collected (Hudson, 2012, pg.1).

On March 1, 2012, Maryland District judge William Nickerson denied cross-motions for summary judgment and the case continued to a bench trial (Hudson, 2012). The trial proceeded with ten days of testimony, and closing arguments were heard November 30, 2012 (Hudson, 2012). Judge Nickerson issued his opinion on December 20, 2012 and in his conclusions of law, he found the Waterkeepers did have standing based on their use (kayaking) of various branches of the Pocomoke River (Hudson, 2012, pg.1, 15). The opinion also stated that if the Hudson farm were the cause of high levels of bacteria and nutrients, then the plaintiff would be affected (Hudson, 2012, pg. 15). However, Nickerson did not find violation of the CWA because the plaintiff failed to show by preponderance of evidence that the high levels of nutrients and bacteria came only from the poultry operation (Hudson, 2012, pg. 19). During the trial, expert testimony revealed a more likely source was manure combined with precipitation runoff from the area where beef cattle grazed unconfined. (Hudson,

⁸ Class A biosolids are “exceptional quality” and have been treated to remove pathogens and metals. Farmers may spread biosolids on their fields for fertilizer. Other biosolid classes or spreading large quantities of biosolids may necessitate a state permit for use and spreading (U.S. EPA, Office of Water).

2012, pg. 7). In dicta, Nickerson found there was “insufficient evidence to impose CWA liability on Purdue” (Hudson, 2012, pg. 18). However, Nickerson also stated in dicta this does not mean integrators could not under certain circumstances be held liable for a CWA violation (Hudson, 2012, pg. 18). Establishing this liability was the foremost goal (in addition to protecting water quality) of the environmental party because integrator liability would force a comprehensive change in the production of almost all U.S. poultry (Assateague Coastal Trust).

Conflict in this case existed because the poultry party wanted to pursue a high-intensity use of land-water resources, while the environmental party desired a low-intensity use. Prior to historical intensification of farming practices, low-intensity use prevailed (Agriculture in Worcester County). Prior to the conflict there is no recognized difference in intensity of use (Duke, 2004, pg.232-33; Duke and Csoboth, 2003, pg. 555). When differences arise regarding use of the resource at stake, it is known as conflict activation (Duke and Csoboth, 2003, pg. 553). A resource at stake is described as the resource that provides environmental services to both of the parties. (Duke and Csoboth, 2003, pg. 553). In this conflict, the resource at stake is the water-land nexus where the high intensity use of excess litter or manure spreading exceeds the capacity of the land and water to absorb and incorporate the excess. The excess causes external effects to the surrounding environment, but also lowers the cost of agricultural production. During the nonactivation period, an informal rights regime prevails, where the high intensity user had a privilege to act as if they had property rights to the land-water resource (Hohfeld, 1917; Bromley, 1989; Bromley, 1991). The conflict arises because a party contests the privilege and, in informal rights regime, has no right to restrain the privileged party (Bromley, 1991 pg.15).

Following the CWA, a series of legislative, quasi-judicial, and judicial decisions led to the assignment of conditional rights to the resource at stake (Duke, 2004; Duke and Csoboth, 2003, pg. 553). Over time, the contested set (or bundle) of use rights continually narrows, as more formal rules are articulated and parties are granted rights or duties to observe the assigned rights (Duke and Csoboth, 2003, pg. 553-54). The judicial process in the *Hudson* case recognized established rights to the poultry party, and placed the environmental party in the duty bearer's position (Hohfeld, 1917, pg. 755-56; Bromley, 1991, pg. 15). Some rights in this case could be considered conditional because Judge Nickerson's opinion implies that, simply because a violation was not found in this case, it does not mean this is true in all cases of agricultural operations (Hudson, 2012, pg. 16-17).

Recent developments in concentrated animal feed operations (CAFO) regulation indicate that each party's set of conditional rights and duties are continuing to evolve, with the poultry parties, as well as other agricultural producers, bearing duties to benefit of the environmental party through land-use and production restrictions (Maryland Department of the Environment (MDE), AFO). In Maryland, all large, medium, and some small CAFOs have to submit for NPDES permits or state compliance (that they are exempt) (MDE AFO). Maryland also has state regulations for feed operations that do not fit the CAFO categories (termed a "MAFO") (MDE AFO). Since 1998, nutrient management laws require management plans to protect water quality, and increasing plan-compliance remains a Maryland Department of Agriculture priority (MDE, 2013). The Hudson farm was a CAFO by both EPA and MDE standards, but at the time of the suit the farm did not have an NPDES permit

(Hudson, 2012, pg.16). Regulations defined the Hudson farm as a CAFO, which means it is required to have an NPDES permit for the regulated area (MDE AFO).

Characterization of Parties

To follow Komesar's participatory approach to comparative institutional analysis and understand how the conflict was processed in *Hudson*, it is necessary to characterize the parties and their ability to articulate and defend their interests in the conflict (Komesar, 1994; Duke, 2003; Duke and Csoboth, 2003). The drivers of participation costs include the party's wealth, numbers, concentration of interest, cohesiveness, stakes per capita, resolution, and participation costs; these criteria define the relative strength of the party's position in the conflict resolution process (Duke and Csoboth, 2003, pg. 553). Sophistication is defined herein by the first four categories (wealth, numbers, concentration of interest, cohesiveness) (Duke and Csoboth, 2004, pg. 560). For example, if a party lacks organization, interests are not concentrated, and membership is large in number, then it may be difficult to gain sufficient monetary support that allows the party to present and argue interests coherently. Thus, they would be lacking in sophistication. The stakes per capita for each party identify the value of the resource at stake for each person in that party (Duke and Csoboth, 2003, pg. 553). A resource at stake (as described above) is the resource that provides environmental services to both of the parties and in this conflict is the uses of the water-land nexus (Duke and Csoboth, 2003, pg. 553). If a party contains great number of members, the stakes in the resource are spread among the individuals. The greater the number of members within a party, the greater the likelihood of heterogeneous interests and the potential for disparate stakes. If the stakes are low, it signals a weakness in the party and affects the ability to have the efficient outcome (right)

awarded in their favor (Duke and Csoboth, 2003, pg. 577). Participation costs are the costs the parties incur to proceed in the resolution processes (Duke and Csoboth, 2003, pg. 552). For example, the expenses of hiring a lawyer or experts are costs the party incurs to participate in the judicial process.

The two general types of parties in this conflict are the poultry producers and the environmentalists. Others outside of a formal organization (dormant members) may also have interests aligned with these parties (Duke and Csoboth, 2003, pg. 559-60, 562 note 82). The poultry producers are high-intensity users because they alter the natural state of the water-land resource. An implication of this behavior is that the high-intensity users have, in effect, limited the use opportunities valued by the low-intensity users for the same resource. The second party is the environmentalists such as the Waterkeeper or the Atlantic Coastkeeper who value the low intensity use of the resource at stake. The impairment of water is caused by handling methods and land characteristics (ditching, soil loading, and storm water runoff), which allow fertilizer (manure or litter) to travel from the farm to the waterway. The conflict's resource at stake is therefore the nexus of land and water that is affected by the high intensity use of land (manure or fertilizer input) which in turn effects water quality relative to intensity of use. Animal agriculture production decisions meet water bodies and have the potential via transportation mechanisms to impact naturally occurring nutrient balances in water bodies and in the Chesapeake Bay. That is not to say these natural levels must never be exceeded, but rather that when they are, a conflict between low-intensity users and high-intensity users activates (Duke and Csoboth, 2003, pg. 541). The characterization of the two parties and their participation costs are described below.

Poultry Party

The poultry parties estimated numbers, wealth, concentration of interest, cohesiveness, stakes per capita, resolution, and participation costs show the party is well positioned to participate in resolution processes. The Purdue Company, Inc. (Purdue) and Hudson are part of the broader U.S. Poultry and Egg industry, and in Maryland the broiler chickens are a billion dollar per year business (National Agricultural Statistics Service; Delmarva Poultry Industry, 2013). The Delmarva Poultry Industry is part of the U.S. Poultry and Egg Association, an industry trade group whose members are producers and processors of poultry and eggs throughout 27 states and worldwide member companies (U.S. Poultry and Egg Association). There are approximately 1,700 broiler chicken farm families on the Delmarva Peninsula who produce 11 million chickens per week (Delmarva Poultry Industry). These chickens are grown for four integrators (including, Tyson and Purdue), which control much of the production process. For instance, the farmers are provided with materials (bedding), services (bird health care), and technical assistance (Delmarva Poultry Industry). The poultry industry has extensive economic impacts beyond production, and it employs more than 14,000 Delmarva residents (Delmarva Poultry Industry). In 2012, the U.S. Poultry and Egg Association funded \$2 million in promotion, education, communication, and research effort (U.S. Poultry and Egg Association). The industry group does not list its annual income from membership, donations, and other support. This association represents the Delmarva Poultry Industry (Open

Secrets, 2013), though other catalytic subgroups of the larger poultry and egg industry exist.⁹

Concentration of interest and cohesiveness of the party are related in that the two parties named in the lawsuit (Hudson and Purdue) are part of the poultry party. In addition, there is a significant concentration of interests and cohesiveness in the high intensity user party because their interests are aligned in producing poultry. It is the primary business, function, and intent of both the named parties and the poultry party at large.

Stakes (as described above) are the value of the resource at stake to the party, or the difference between their received value with and without the resource at stake (Duke 2004, pg. 242). The resource at stake in this conflict is the use of the specific land/water nexus on and near the Hudson farm. The various ways poultry litter is managed affects the costs of the poultry production business, and some techniques that lower the costs of production (high intensity, large litter production) may also create external effects to the environment. The poultry party's stakes per capita are described as moderate—meaning important but not the most important aspect of production—because the costs of managing the poultry litter may be low or high depending on the individual poultry uses that might be assigned rights. Costs of production increase through regulation, which currently include nutrient management plans, installing best management practices, and permitting for CAFOs. It will be

⁹ Catalytic subgroups as described in Komesar represent a concentrated group within a greater group that operate on behalf of the greater group and concentrated interests of the catalytic subgroup may spur legal action on behalf of the greater group (1994).

qualitatively argued below that the stakes for the poultry party are higher than the stakes for the environmental party.

In litigation, Purdue supplied Hudson with expert witnesses and lawyers that argued the case on the Hudson's behalf (Hudson, 2012 pg. 1, 7). This is because a loss in the *Hudson* case could have ramifications for the poultry integrator (Edwards, nd). The cost of litigation for Hudson and Purdue of this particular case can be estimated because Purdue requested \$3 million be covered by the Waterkeepers Alliance for the costs of the frivolous lawsuit (Associated Press, 2013). Judge Nickerson denied awarding court fees as (generally) the lawsuit was not "frivolous, unreasonable, or without foundation" (Associated Press, 2013). If lobbying costs are considered an indication of participation costs in the legislative process, the poultry and egg industry spent \$840,000 in 2013 with a recent egg and poultry industry high of \$1.6 million in 2012 (Open Secrets, 2013). A portion of this total could be attributed to concerted action by the poultry party.

Environmental Party

The environmental party's estimated numbers, wealth, concentration of interest, cohesiveness, stakes per capita, resolution, and participation costs show the party is not as well positioned to participate in the formal resolution process as is the poultry party. According to their website, Waterkeeper Alliance, Inc. is an organization focused on helping other watershed organizations fight for the right to clean water (Waterkeeper Alliance). Member organizations, such as the Assateague Coastal Trust (ACT), receive support from the Waterkeeper Alliance to battle the common pollution issues that face many watersheds today (Waterkeeper Alliance, Mission). The Waterkeeper Alliance states that the public is the owner of waterways,

and “pollution is theft” (Waterkeeper Alliance, Rights). Further, when government fails “it is the right and responsibility of citizens to enforce environmental laws and protect our right to clean water” (Waterkeeper Alliance, Rights). The ACT has more than 5000 members and works to protect the Delmarva Peninsula and the Atlantic Coastal Bays watershed through advocacy, conservation and education (Assateague Coastal Trust, What We Do). The ACT, a membership organization of the Waterkeeper Alliance, has a small staff with an executive director titled the Assateague Coastkeeper who is charged with patrolling and monitoring the Delmarva Peninsula watersheds (Assateague Coastal Trust, Assateague Coastkeeper). The Waterkeeper Alliance has over 200 organizations in 23 countries on six continents (Canfield, 2013). The Waterkeeper Alliance 2012 audited financial report lists net assets at \$1,611,579 and the ACT Internal Revenue Service Form 990 lists net assets at \$256,331 (Waterkeeper Alliance, IRS 2012; Assateague Coastal Trust, IRS 2012).

There is relatively less concentration of interest and cohesiveness of the environmental party when compared to the poultry party. One mission of the Waterkeeper Alliance and ACT is to protect the waterways through active citizen involvement (Waterkeeper Alliance, Mission). However, these interests are not well aligned: Waterkeeper Alliance, as the larger group, has a broader focus (e.g. global climate change and clean and safe energy) than the ACT because of its international and national focus (Waterkeepers Alliance, Advocacy Campaigns). In addition, this party would have: (1) active members; (2) members who value clean pollutant free water and may contribute but do not actively participate in the ACT (or Waterkeeper Alliance) activities; and (3) nonmembers who share many interests with these groups but do not participate. The latter group is likely to be very large and likely constitutes

a dormant majority (Komesar, 1994; Wagner, 2013). With a small paid staff, ACT is able to provide structure and action for its members relative to other watershed organizations who may not have paid staff. Being a member of the Waterkeeper Alliance focuses ACTs organization campaigns and goals and therefore provides cohesiveness to the party relative to other less organized environmental parties, such as smaller watershed groups. The diffusion of members' interests and small active core characterizes many environmental organizations and influences the impact the groups have on individual issues outcome.¹⁰

Per-capita Costs and Benefits of Participation

The overall stakes per capita are the value of some degree of protected access to the resource at stake to each member within the respective parties (Duke, 2004). This changes with every institutional change. The participants compare the potential benefits of change with the costs of participating in the resolution process (Duke, 2004). That said, one party can often force another party to participate by unilaterally seeking resolution (such as suing) (Duke, 2004). There are differences in the calculation of stakes for the two parties. Value of the right for the poultry party is observed as private cost of more expensive management of the litter, which in turn affects nutrient and bacteria levels entering proximal water bodies. The environmental value derives from the right to impose these management costs on the poultry party

¹⁰ For example, Kempton et al. (2001) found a surprising number of environmental organizations were diverse and politically focused with core members focusing on essentially the legislative and political process with a lack in ability to motivate the largely inactive local stakeholders.

and an improved use of low-intensity activities, if the water has less pollution loading. At a simple level, one compares the high intensity use of the water-land nexus by Hudson to that of the kayaking of Waterkeepers and the groups they represent along with other low-intensity activities. In the bilateral world of one farm and a group of affected environmentalists, the value of the poultry stake is higher because they face real costs in changing management practices. However, there would be almost no perceptible change in water quality from this one farm changing practices.

Waterkeeper and ACT represent use values of environmentalists that are kayaking on the Pocomoke River. If all farms would be forced to bear expanded management costs, then water quality would indeed improve and the value of the environmentalist's stake in water use would expand to include activities such as swimming.¹¹ However, water quality would not be substantially improved by winning this one case against one farm. Therefore, the value of the right is lower for the environmental party as a whole. However, the conflict had broader implications than simply the activity of Hudson's farm, in isolation.

Resource allocation efficiency is evaluated with two states of the world that might arise from any institutional change, one where an expanded right resides with the environmental party and one where a competing right resides with the poultry farmer party. The Waterkeeper Alliance's Clean Water Defense and Pure Farms, Pure Waters campaigns of list goals of strengthening regulatory and legal action and

¹¹ A wealth of research conducted over the past several decades has searched for the economic value of natural resources and ecological services. Recent literature describes the multiple difficulties in not only determining what to value but also magnitude of the value (e.g. Keeler et al., 2012; Van Houtven, Powers, and Pattanayak, 2007).

“eliminating the impacts of factory farms” (respectively) (Waterkeeper Alliance, Campaigns). These campaigns indicate there is high value in spending the group’s resources promoting the removal of industrialized farms; nonetheless, diffuse membership dilutes the per capita stake of the expenditure. If the *Hudson* conflict was decided differently and (at the extreme) the environmental party obtained an injunction against Hudson, pollution entering the Chesapeake Bay would remain. That is, by winning this particular case there would be no impact on pollution overall because conflict represents an incomplete portion of the impact of approximately 6,000 poultry houses in the Delmarva Peninsula (estimate from 1999) (Goodman, 1999). Further, if some poultry exited the industry, it would likely be replaced by other land uses that also contribute nutrients to the waterways. Therefore, the direct stakes of the active and dormant members of the environmental party are comparatively lower because not obtaining the right of injunction still allows some use of the resource. However, if the poultry party lost and the right given to the environmental party in the form of an injunction, the stakes (in the form of costs of production or being forced to cease operation) would readily change. That said, there is a potential for a precedent-setting outcome (if an injunction was granted) that could trigger gains in related water quality conflicts by enforcing the cost of water quality protection borne by the poultry party. This dynamic impact is difficult to estimate, and it helps explain why the Waterkeeper Alliance likely devoted so much effort to this conflict and why Purdue was named as a defendant.

The resolution and participation costs of the environmental party are estimated to be lower relative to those of the poultry party. The Waterkeeper Alliance was formed in the 1990s from the Hudson Riverkeeper watershed organization. Both

groups concentrate on fighting water pollution through litigation (Waterkeeper Alliance, Who We Are). Unlike the poultry farmer party, the environmental group does not appear to have a specific industry or interest group that concentrates on lobbying alone (Open Secrets). The Assateague Coastkeeper and other paid staff of the Waterkeeper Alliance lobby as part of their job duties, and advocacy appears to be one of the top duties for the Assateague Coastkeeper (Assateague Coastal Trust, Assateague Coastkeeper). The operational model for the Waterkeeper Alliance is to engage local law clinics such as occurred with the Hudson case. The University of Maryland's law clinic has been criticized for representing the Waterkeepers, not only because the case was ultimately assessed to be weak by the judge but also because the clinic is taxpayer-funded and yet was attacking an important state industry (Olson, 2012). From the judicial opinion, one infers that the experts and argument-quality of the Waterkeeper were of lower quality than that of Hudson and Perdue.¹² In sum, the costs of the environmental group's participation in the conflict resolution process were lower compared with the poultry farmer's costs largely because the multibillion dollar poultry industry is able to provide better support through the judicial process than grassroots-volunteer organizations. This does not mean that "industry" should win over the "environment," just that the monetary status and cohesiveness of the poultry party provide better opportunities for positive outcome in the judicial process.

The poultry party is highly organized, concentrated, and sophisticated with at least 14,000 members in Delmarva. (Look what the Chicken Industry is Doing for

¹² Hudson, 2012, pg.1. It can be inferred from Judge Nickerson's comments during presentation of the facts and opinion that the Waterkeeper Alliance argument, evidence, and presentation of facts was substandard compared to Hudson's.

Delmarva). The cohesion derives from the vertically integrated nature of poultry production in the region, where a corporate integrator closely monitors the production process and inputs managed by the “grower” farmer. The stakes per capita are medium due to varying costs of production. The costs of participation in formal resolution are high but are spread over many well-organized groups, meaning that the average participation costs are low. Most formal participation would take place, due to the concentration of interests, with representatives such as lawyers, lobbyists, and experts.

The stakes per capita for the environmental party are comparatively low, as argued above. Member numbers for the party are not readily available, but this party likely contains a large dormant population. However, the effect of this particular case on the outcome of pollution reduction to the Chesapeake Bay is effectively zero because it ostensibly affects a single operation. If the judgment affected precedent, then the remaining 6,000 poultry houses might be considered and the stakes per capita would be higher, but the costs would also be higher in organizing the disparate environmental interests. The costs of participation in the narrow, one-farm conflict are low because there is a catalytic subgroup, but the sophistication is relatively high because of this catalytic subgroup (Komesar, 1994).¹³ Stakes per capita and factors described above are an important for consideration in the next section that analyzes institutional efficiency and fairness.

¹³ As described in Komesar (1994), the “catalytic subgroup” is a smaller group within a dormant majority that operates to activate the dormant members through collective action.

The summary of the party characteristics reveals that protracted, complex conflict resolution exposes the strength of the poultry party and the comparative limitations of the environmental party. The poultry party also has a higher valued use for the resource at stake—this is due largely to the direct stakes per capita, which are low for the environmental party. This, in turn, will affect the efficiency and fairness of the resolution processes further described below.

Transaction Outcome and Rights Allocation

Environmental transactions are instances where two parties challenge one another for presumptive or legal control over the resource at stake (Duke, 2004; Duke and Csoboth, 2003). In this conflict, environmental transactions occur in market, legislative, and judicial resolution processes throughout the history of the dispute, over the course of which specific rights of the two parties are assigned and made more specific. During this period of dispute processing, control over the resource at stake has the potential to be reallocated. The transaction events move through general and specific resolution processes that determine the outcome and resultant resource rights allocation. General resolution processes are: market, quasi-market, judicial, quasi-judicial, legislative, moral suasion, and alternative dispute resolution (such as mediation or arbitration) (Duke, 2004; Duke and Csoboth, 2003). Specific resolution processes are the constructed arenas where the transaction outcomes are determined, such as a given state court of first instance (Duke, 2004; Duke and Csoboth, 2003). The specific resolution processes may occur at federal, state, and local levels and in legislative, quasi-judicial, and judicial bodies. The quasi-judicial bodies enact regulation following federal or state statute (laws) and have ability to impose fines, approve or decline project permits.

Environmental conflict originates in an informal (or presumptive) rights regime, where the high intensity user of the resource acts with privilege and shifts costs via negative externalities at will to others (low intensity users) (Duke, 2004; Duke and Csoboth, 2003). The informal rights regime ends, and a formal rights regime begins, first with local ordinances, state and/or federal statute and then is followed by administrative rules, (i.e., nutrient management regulations, water quality standards, and pollution discharge permits) that restrict the rights of the high-intensity user (i.e., animal feed operations) (Duke, 2004; Duke and Csoboth, 2003). The parties' interests conflict over the rights allocation, where each party wants the fullest set or bundle of rights to access the resource at stake. The bundle of rights term is used to explain that property rights include multiple pieces, not just one right (Klein and Robinson, 2011; Alchian and Demsetz, 1973; Demsetz, 1967).¹⁴ The environmental party received rights under the CWA that are expressly granted (no unauthorized discharges to Waters of the United States are allowed). However, unallocated rights remain (nonpoint source) and the environmental groups seek to obtain rights through pursuing point source operations in litigation.

Informal Rights Regime

Environmental transactions allocate rights, progressively moving the rights regime from informality to ever more formality (Duke and Csoboth, 2003). In an informal (or presumptive) rights regime, formal institutions are not present to restrict

¹⁴ For example, a landowner may have a stream on his property, but the right to use the stream as he wishes may be restricted by local, state and federal law, the government also has the right (through statute) to collect tax on the property.

explicitly or liberate rights (Commons, 1931; Bromley, 1991). Nonactivation is a period of time when the resource at stake is not scarce, meaning the low-intensity use is maintained by default (Duke and Csoboth, 2003). In the Hudson conflict, the transactions begin with an informal rights regime and a prolonged period of nonactivation, but this arrangement was altered during the agricultural industrialization period with attendant water pollution. From the post-colonial era to the industrial era, growth and lack of municipal and regional infrastructure allowed sewage and other pollutants to be discharge directly to streams. Population growth and market regime encouraged increasing resource use through the 1800s (timbering and bog iron mining), (Sipple, 1994; Holden, nd) which presumably created small quantities of pollution.

In early America, the privilege holders were landowners that used their land in ways that negatively affected water quality. Based on recent studies that show water quality degradation with deforestation and mining, inference that complete timbering of swamp cedar and bog iron mining presumably negatively affected water quality (e.g. Calder and Maidment, 1992). The conflict arises because interests are in contrast between parties regarding resource use. Water quality degradation constitutes externalities, which occur when one party has the privilege to pollute and no right exists for the other party to stop the pollution. The costs of pollution are borne by society, specifically those who value the low-intensity use. In early America, institutions were not formally in place to process the conflict of increasing water pollution due to various natural resource (land) uses. Also, at this time, the relative value of agricultural and other extractive production likely exceeded the value of a clean environment for the early Americans. As such, during these informal rights

regimes, there was likely little political pressure for legislation that altered the status quo to protect the environment and restrain landholders. Presumptive rights would thus persist until pressure grew by the increasing relative social value of water quality as part of the increasing scarcity of clean environments.

Formal Rights Regime

Through the first half of the 1900s, only modest institutional change occurred via statutes and regulations, which allocated particular rights and offered limited restrictions on landowners through zoning. It was in the early 1900s, that institutions truly constrained land use behavior that impacted water pollution. Throughout early America in the 1920s, zoning laws and ordinances were used to determine appropriate land uses, which allocated rights among private property owners (Kaplow, 2003).¹⁵ In the Pocomoke watershed and Worcester County, agriculture was a leading land use and current zoning reflects high-relative-value agricultural land uses (Maryland Department of Planning Land Use Map). Zoning ordinances in Worcester County were used to allocate rights to the high and low intensity users through the state and local legislative processes; certain industries were restricted to particular areas (i.e., zones) for early planning purposes.

The federal Water Pollution Control Act (WPCA, 1948) and amendments (CWA, 1972; CWA, 1987) allocated rights through the federal legislative process—

¹⁵ As Kaplow points out: “There were early land use laws in this country and as early as 1692 Massachusetts towns relegated the location of slaughterhouses to upwind nonresidential areas. Later precursors to modern zoning were fire districts, areas in certain cities where wooden buildings were prohibited” (Kaplow, 2003). Zoning as a comprehensive institutional restriction on land use came much later in New York 1916 (Kaplow, 2003).

the U.S. Congress (CWA 33 U.S.C. § 1251 et seq.). The WPCA and amendments established a process that could be used to restrict the rights of landholders and provided conditional rights to environmental interests. The CWA began the formalization of rights, thereby removing the presumptive right from high intensity users and began to require sharing of costs through technology improvements and decreasing emissions. The CWA also required the states to set standards, control pollution in waterways, and contained the provision for low intensity proponents (environmentalists) to identify pollution externalities and object to high-intensity use via quasi-judicial or judicial processes. The WPCA, amendments, and state statutes provided a process to liberate or restrict landowner's rights through the permitting process as described below.

It is well known that the CWA exempted agricultural nonpoint source discharges directly, however, the EPA's concentrated animal feed operation rules ("CAFO Rules" 2003-2008) required states to require National Pollution Discharge Elimination System (NPDES) permits for CAFOs, and required land application of manure to be addressed (U.S. EPA Concentrated Animal Feeding Operations (CAFO) - Final Rule). Poultry (and other animals) that are confined and of a certain size (by animal unit or poultry house size) can be considered a CAFO based animal numbers and the configuration of the farmland (MDE AFO). In effect, the agricultural nonpoint source became a point source in need of an NPDES permit by definition when the operation is of a certain size and "...is designed, constructed, operated, or maintained, such that a discharge to surface waters of the State WILL occur" through ditches or pipes (MDE AFO). The CAFO rules and other Maryland statutes such as the Water Quality Improvement Act further constrained and allocated formal rights

from the high intensity party to the low intensity party (MDE WQIA). The state promulgated nutrient regulations that restricted farm landowners (high intensity users) through requirements for litter handling, farm configuration (ditching piping, spreading) and farm discharge during weather events (storms). Again, the environmental party won some rights through the high intensity users (poultry and other animal farms) altering their desired production process and bearing costs.

Rights were largely defined for point sources with the enactment of the CWA; conversely, the CWA largely left nonpoint (field) agricultural sources of discharge unregulated. Indeed, following the CWA, the environmental party did not have well-defined rights specifically because CAFO thresholds exclude many operations and because nonpoint sources and agricultural storm water are excluded from regulation (CWA). The latter two sources constitute a recognized majority of agriculture pollution entering the Chesapeake Bay (The National Academies Press, 2011). In pursuit of the unallocated rights, the environmental party in the *Hudson* case exercised its express right designated in the citizen suit provision of the CWA (CWA). To understand how the CWA and ensuing federal and state regulation does not create a fully formalized (Hohfeldian) rights regime (only conditional rights to the environmental parties), environmental transactions of *Hudson* are detailed below (Hohfeld, 1917; Bromley, 1991). The citizen suit provision enabled this conflict to reach judicial resolution.

Comparative Institutional Analysis

Moving from informal to formal rights regimes involves allocation of rights to the parties based on resolution processes through the creation of institutions. The process by which these rights were assigned is important in the comparative

institutional analysis below, which will be completed in two steps. Each instance where allocation of rights is possible constitutes a transaction. The transaction outcomes assign rights and are used as in Duke (modifying the method of Komesar) to assess two goals: The Coasean substantive efficiency of the rights allocation; and (2) the procedural fairness of the dispute processing (Komesar, 1994; Duke and Csoboth, 2003).

Procedural Fairness

The assessment of procedural fairness is conducted by evaluating the representation of parties' interests in the conflict resolution process. The parties' characteristics described above are used to assess each party's ability to advocate their positions in the resolution process and point to strengths and weaknesses that affect individual transaction, and ultimately resolution process outcomes. In the water-land conflict and *Hudson* case, transaction outcomes and rights allocation in the legislative, moral suasion, quasi-judicial, and judicial resolution processes are examined and assessed for procedural fairness.

Legislative

Procedural fairness assessment of the legislative actions includes the relevant federal and state statutes: CWA and Water Quality Improvement Act (Maryland nutrient management law). The legislative process creates the institutional structure by which disputants can articulate their interests and compete for formal rights. It also establishes some formal rights and duties such as the requirement that point sources follow NPDES procedures or farmers comply with a basic nutrient management planning and implementation.

Prior to the initial water quality statutes, no formal process existed for the environmental party to articulate its interests with respect to environmental quality. Legislative resolution thereby provides a way for the environmentalist's voices to be heard without directly creating the outcome. In addition, the legislative process is a low-cost way, albeit indirect, for environmentalists with low per-capita stakes to participate. Similarly, the poultry industry, like all low and medium per-capita stakes parties that are source of water quality loadings, now have an ability to defend their practices from legislative constraints. So, the process of creating these statutes offered considerable procedural fairness. Indeed, one interpretation of the CWA is that the nonpoint sources were largely exempt from control, while the point sources were now subjected to a regulatory process. This outcome matches the interests of the two parties here, suggesting that both were able to articulate their interests without securing full rights over one another's uses of the resource at stake. Subsequent statutes, however, tended to increase the regulatory processes available, which tended to support the environmentalists' articulation of their interests. This suggests robust participation by environmentalists. In contrast, the fact that there still is little direct, rigorous statutory control over many nonpoint sources suggests that the poultry farmer party (and agricultural parties in general) also continued to participate fully in the legislative process in the years following the CWA.

Moral Suasion

Moral suasion is a resolution process usually used by environmental group to place pressure on entities that they claim are harming the environment. It is an informal process in that no formal institutions are created; instead, environmental parties persuade emitters to abate, voluntarily, some level of discharge. In this

conflict, the environmental party issued press releases to raise negative profile of poultry party. Information was used in the press releases—specifically, that the pile observed during the fly-over was poultry manure and a “mixture of human waste and poultry manure”—that was deemed incorrect in litigation¹⁶ indicates the fundamental imbalance of participation in the moral suasion resolution process. Furthermore, Hudson and Purdue had little ability to correct or challenge the contentions made against their activity. In sum, moral suasion had procedures that did not generate fairness in this conflict. That said, moral suasion is not used because it is procedurally fair. It is not a public forum or other means where both parties participate and are heard. The Waterkeepers group likely saw moral suasion a way to raise awareness and achieve some conflict resolution without having to use formal conflict resolution procedures.

Quasi-judicial

Quasi-judicial resolution processes involve major rules and more specific interactions between the poultry party and the environmental party through the Maryland Department of Environment (MDE) visits in December 2010 and January 2011. The poultry party is affected directly by federal and state CAFO/AFO/MAFO rules and regulations. The rule-making quasi-judicial resolution process is governed by institutional protections of procedural fairness within the Administrative

¹⁶ “After the discovery that the pile on the Hudson Farm was bio-solids, and not chicken manure as first alleged, Phillips and Waterkeepers continued to represent to the press and public that the pile contained a mixture of human waste and chicken manure...Phillips continued to state in press releases that the pile contained chicken manure, despite the fact that she had no evidence to support that representation” (Hudson, 2012, pg. 13).

Procedures Act (Administrative Procedure Act (APA), 2006). The APA requires the rulemaking process include stakeholder and citizen input before rules are promulgated or to offer affected parties resource through judicial review if rules are deemed in excess of the agencies authority (APA, 2006). This key provision attempts to ensure that the voices of different interests are heard during the rule-making process. However, recent analysis suggests there may be serious impediments to full participation of affected stakeholders (Wagner, 2013).¹⁷

Indirectly, a host of agency decisions shape the agricultural industry and, in turn, affect the incentives for poultry farmers to select the size and management option on their farms. Formal rights regimes affect the location of processing and marketing facilities, management of the size and configuration of operation, and waste quantity and management. There also are a growing number of incentive-based programs to encourage agricultural operations to retire lands and adopt management practices that decrease nutrient loadings to water bodies. These institutions complicate the analysis of quasi-judicial resolution processing because they do not directly affect the resource at stake and some of these policies are voluntary.

In contrast to the legislative process' more general guidelines on how to assign rights, enforcement activity by the MDE directly affected the resource at stake and led directly to the litigation. The MDE visits to the defendant's farm were in response to the Waterkeeper's allegation of unpermitted release from improper poultry manure storage on the Hudson property. During the MDE's first visit in December 2009, an inspection revealed that the pile was not manure but bio-solids from the Ocean City

¹⁷ Maryland state regulation has similar public notice and participation requirements in the permit process for CAFO/MAFOs (MDE AFO).

Wastewater Treatment Plant (Hudson, 2012, pg. 11). The inspection found the poultry areas did not show evidence of discharge (Hudson, 2012, pg. 11). A second visit by MDE on January 26, 2010, included water sampling to determine if the bio-solids pile contributed residual pollution to the water (Hudson, 2012, pg. 11). Hudson was assessed a fine on the first visit for “improper storage,” but an administrative judge declined to impose the fine (Hudson, 2012 pg. 11). No fine or other violation was found on the second visit (Hudson, 2012 pg. 11). No discharge was observed from the poultry houses; however, the facts of the case suggest that cattle manure was in direct contact with the ditches on the farm (Hudson, 2012 pg. 16-20). Procedurally, the quasi-judicial process exhibited some fairness to the environmental party because the allegation of a regulation violation made by the Waterkeepers was investigated. However, from the perspective of Hudson, it may appear procedurally unfair to be targeted with an enforcement action based solely on the complaint of an external party and singled out for enforcement from the broader poultry farming population. Beyond the selectivity of the enforcement, no evidence could be located that the MDE overstepped regulatory authority when investigating and determining apparent or real violation of state or federal law. Waterkeeper’s allegation of discharge from the “pile” or discharge of “poultry manure” was thoroughly investigated. It is clear from findings of fact that high pollution levels were in water samples taken from the proximal stream by the MDE and the ACT; however, the MDE was responding to the allegation of the point source discharge from a pile or the houses, not the source related to the cattle in the fields (Hudson, 2012, pg. 16-19).

Judicial

There was only one judicial transaction in the *Hudson* conflict. The judicial process was similar to the quasi-judicial process in that the case focused on the violation reported by the Waterkeepers of discharge from poultry manure in waters of the United States. The citizen suit provision allowed the environmental party to access the judicial process directly without relying on quasi-judicial action. This ability to participate contrasts with the coerced participation by Hudson. Despite the ease with which they accessed the process, the environmental party seemed to have difficulty articulating its interests with a compelling argument. The reading of Findings of Fact and Conclusions of Law written by Judge Nickerson reveals that the Waterkeepers were pursuing the wrong source of pollution and were unable to provide a cohesive case (Hudson, 2012, pg. 16-19). The industry support for the poultry party may have provided more expert support for the defense in as much as maintaining focus on the claim made (Save Farm Families, 2012).¹⁸

Substantive Efficiency

The transactions in the formal rights regime allocate rights relative to the resource at stake, which can be analyzed in terms of the goal of substantive efficiency. Substantive efficiency will be determined using a Coasean analysis (Coase, 1960) whereby efficiency is enhanced when rights are allocated to the party that has the highest social value for the resource at stake (Coase, 1960; Duke and Csoboth, 2003). As argued above, the poultry party appears to have a higher value for the resource at

¹⁸ This website offers the fact that the Hudson's were responsible for their own representation and Perdue did not provide legal support.

stake because the resource at stake involved a minimal impact on overall water quality, as it was related only to the Hudson farm. Therefore, processes that tend to allocate rights to the poultry party will tend to produce substantive efficiency.

Legislative

The legislative resolution processes tended toward substantive efficiency. Though the statutes establish a process that might restrict industries and firms from unabated pollution, the statutes are not likely to end all activity in any industry. Moreover, statutes tend to put little restrictions on agriculture as a practice (unlike industrial or municipal point sources) and completely exempt nonpoint sources. In sum, the legislative resolution established processes that might potentially be used to benefit the environmental party, but on balance they did not entirely restrict the poultry party and thus tended toward efficiency.

Moral Suasion

The moral suasion resolution process in the *Hudson* case consisted of using provocative press releases. The press releases in the *Hudson* case were, obviously, to benefit the Waterkeeper interests. Although no rights were allocated and the process, it tended to work against the goal of substantive efficiency because it attempted to assign rights to the lowest-valued user. That said, moral suasion was incomplete. Many of the dormant stakeholders that the Waterkeeper Alliance may have been attempting to sway into action were not activated.

Quasi-judicial

The quasi-judicial process assessed against the goal of substantive efficiency reveals whether the right resides with the highest valued user. In the case of MDE

visits, some rights were conditionally assigned to the Waterkeepers when a fine was assessed to Hudson. However, a fine was not imposed in a second inspection. Constraining the large industrial poultry operations defined as CAFOs within the CWA statutory limits tended to allocate rights to the lower-valued user. In sum, the quasi-judicial restrictions on the Hudson were slight, and in sum the conditional rights allocated tended to benefit the poultry party. Therefore, the quasi-judicial process tended to generate substantive efficiency with respect to the resource at stake in the *Hudson* conflict.

Judicial

The judicial process assigned rights to Hudson, which resulted in achieving the goal of substantive efficiency. The court questioned the merit of the environmentalist argument, thereby raising the evidentiary bar for future cases. In effect, this protects farming operations from threat of poorly construed accusations and thereby allocates the right to unencumbered operations.

Comparative Institutional Analysis Summary

The parties' interests are incompatible because intensive agriculture wants to use the same water for discharges that environmentalists want free from excess nutrients. The environmentalists view this high intensity land use, when manure is spread beyond the capacity of the land to absorb the nutrients, as an impingement on their right to clean water. Waterkeepers want the right to prevent environmental costs by using formal institutions to assign duties to high intensity agriculture, such as concentrated animal feeding operations, preventing any high intensity agricultural use that negatively affects water quality. Using the judicial process resulted in the

outcome, finding that the Hudson's are conducting permissible operations under the current law.

The comparative institutional analysis of this conflict required that the performance of each resolution process be compared with respect to a goal. The goal of fairness was best achieved in legislative resolution where both parties were represented by catalytic subgroups with access to the process. The quasi-judicial and judicial processes incompletely delivered procedural fairness, and moral suasion was unfair to the poultry party. The legislative, quasi-judicial, and judicial processes tended to be substantively efficient with rights allocated to the highest valued user. The moral suasion process did not result in rights assignment, but if successful would have been inefficient. Among the informal processes, the market tended to be efficient but unfair, as the environmental party did not have the ability to participate. Therefore, this analysis concludes that the legislative process was best positioned to achieve the goals of procedural fairness and substantive efficiency in resolving this particular conflict of discharges from a concentrated animal operation. This analysis should hold lessons for similar agricultural-environmental conflicts at the nexus of land and water.

Implications and Conclusion

This comparative institutional analysis was performed to understand the relative performance of dispute processing in the CWA and ensuing resolution processes allocate rights to parties involved in environmental conflict over high intensity land use and water quality degradation. The comparative institutional analysis reveals the resolution process (market, legislative, moral suasion, quasi-judicial or judicial) performed the best in terms of the social goals of substantive

efficiency and/or procedural fairness. Methods of analysis followed Komesar's participation centered approach and Duke's transaction analysis at each stage of the conflict (Komesar, 1994; Duke, 2004). Transaction outcomes and description of the poultry party and the environmental party positions revealed whether the goals of Coasean substantive efficiency and procedural fairness were achieved in each resolution process. If rights were assigned to the highest valued user, in this conflict the poultry party, the result was Coasean efficiency. If each party's position allowed for sophisticated, organized participation in the resolution process, then procedural fairness resulted.

The purpose of the analysis was to examine the resolution process of the environmental conflict issue of "Who bears the external cost of the high intensity use of the resource at stake?" (Duke and Csoboth, 2003). In the *Hudson* case, the environmental conflict was over intense land use that triggered a challenge by the Waterkeepers. The intent of examining this water-land conflict and case study was to determine if any one resolution process performed better than others when compared with the goals of efficiency and fairness. The legislative resolution process performed the best in terms of fairness and efficiency, but this result may be surprising and difficult to apply in future water-land nexus conflicts. Simply, legislative resolution performed the best but it never addresses, conclusively, nonpoint or other obvious sources such as restrictions on cattle in the field. The judicial process revealed, clearly, that nutrients and bacteria were present in water near the farm, but the outcome validated Hudson's interests in remaining unrestrained. The judicial result was driven by the relative weaknesses of the environmental party argument and, in effect, recognized the higher social value of the poultry party.

The quasi-judicial processes implemented and enforced rules of the legislative process. The legislative process established the rules of future processes that remedy conflict between the incompatible interests of the two parties. In a previous comparative institutional analysis of environmental conflict, the judicial and quasi-judicial process were fair and efficient and yet the quasi-judicial process was better suited to handle scientific complexity inherent in a complex environmental conflict (Duke and Csoboth, 2003). However, the Hudson conflict can be considered “incompletely processed” due to the poorly argued environmental interests, framing and pursuing the wrong problem (poultry nutrient and bacteria source as pollutants rather than the actual sources). The case was important in the larger conflict of Chesapeake Bay, but is a poor example of individual conflict resolution. The resolution process resulted in substantive efficiency and procedural fairness but the result of the resolution process did not adequately address the conflict over the resource at stake. Simply assessing either the highest valued use through substantive efficiency or procedural fairness in one case does not address the deeper, larger conflict of recognizing the unallocated rights that are sought by the environmental party. The *Hudson* case is an example of the environmental party inadequately arguing for their interests in accordance with the institutions established by the legislative, quasi-judicial, and judicial resolution process.

The *Hudson* decision leaves the possibility that runoff from agricultural fields could be considered a violation of the CWA. Evidence that juries find agricultural sources (even “diffuse” sources) in violation of the CWA can be found in *CARE v. Southview* (*CARE*, 1994). These cases indicate that the common law movement may be to place agricultural nonpoint source discharges under point source definitions

where appropriate, or lead to a clear definition of more sources that clearly generate pollution and can be considered for CWA violation. The path forward for nonpoint source may be an extension of existing statutory language to include more practices, rather than regulate nonpoint sources under new amendments to law (Centner, 2010). Other paths suggested in the past are more regulatory flexibility in instituting the CWA goals and crafting legislation to insulate outcomes from political bias (Zaring, 1996)

To move toward resolving the conflict of intensive land use and water quality externality of CAFOs, the quasi-judicial institution should be the best suited to settle disputes through scientifically based application of law. The quasi-judicial institution is moving toward tighter regulation in agriculture and, in the future, Hudson will operate under a NPDES permit. However, the regulators, as with many permit restrictions on discharges, will be limited by the ability to monitor completely the CAFOs and enforce the permit conditions. Sorisio argued that a solution to lax enforcement by the Department of Agriculture demonstrates the power of enforcement should be with the Department of Environment (Sorisio, 2003). Some impediments to judicial and quasi-judicial processes were highlighted in this case study and are found in tort cases as well (Wagner, 2007). The costs of information for the environmental groups is an important consideration as they prepare their litigation or complaint. Wagner summarizes even the “‘worst’ regulatory litigation” have value in that they can lower the cost of information for potential future cases by revealing information that may have previously been unobtainable by opposing parties (Wagner, 2007 pg. 307). Unfortunately—as pointed out—the Waterkeeper maintained status with

erroneous information in pursuit to the only source that is was regulated on the Hudson farm, the poultry operation.

In the event another catalytic sub-group pursues litigation, they will (hopefully) be guided by Judge Nickerson's opinion and should frame their legal and scientific pursuit of rights better. The conflict may be better resolved in the local legislative institution where zoning or other regulation changes mitigate intensive agriculture's influence on water bodies by requiring buffers. In certain situations, the conflict may be resolved in a market structure where incentives to reduce intensive land use provide farm benefit as well as water quality benefit. These incentives are currently being explored and developed within quasi-judicial institutions and could be structured to provide conflict resolution through market transactions.

Chapter 3

COMPARATIVE POLICY ANALYSIS: NUTRIENT MANAGEMENT, NUTRIENT TRADING, AND MONITORING COST

Obtaining nutrient reduction from nonpoint source agriculture poses some of the most difficult challenges in efficient policy design and implementation. The dispersed and stochastic nature of agricultural nonpoint sources (Ribaudó and Caswell, 1999) makes direct analytical monitoring of excess nutrient discharges costly (National Research Council, 2011). Monitoring cost is potentially one of several reasons nonpoint source agricultural activities are excluded from the definition of point sources that discharge nutrients and are exempt from the Clean Water Act (Kaufman et al., 2014; Wainger, 2012; U.S.C 33 § 1362; Gould, 1989; Williams, 2002). As described further in this chapter, there exists a variety of monitoring definitions, and associated costs of monitoring, to determine water quality improvement.

In the United States, nutrient reduction policies for agricultural nonpoint sources are predominantly flexible and incentive-based (Dowd et al., 2008; Shortle et al., 2012; Ribaudó et al., 2014), but they have limited success (Williams, 2002; Ribaudó et al., 2014). Because of the limited success, and the impending 2025 TMDL (U.S. EPA, 2010), many states surrounding the Chesapeake Bay have adopted nutrient trading policies to encourage agricultural nonpoint source participation in reducing excess nutrients. Water quality trading was introduced through pilot programs about 25 years ago and has gained prominence in the last 12 years as the U.S. EPA began to encourage trading as a way to cost effectively reduce nutrients in waters of the U.S. (Shortle, 2012). Trading program development was incentivized through funding by the U.S. EPA (U.S. EPA Targeted Watersheds Grants) in the Chesapeake Bay as a

way to “achieve early reductions and progress towards water quality standards and to reduce the cost of implementing TMDLs for impaired waters” (MDA, 2008, p. 6).

Nutrient management planning, and other policy instruments to address widespread nutrient excess, have been used for several decades (Beegle et al., 2000). Federal law delegates authority to the states to identify and manage nonpoint source agricultural pollution. States developed varying forms of nutrient management policies from regulation to incentive-based programs to address nonpoint nutrient pollution. The varied policies for nonpoint source nutrient reductions from agriculture make policy analysis complex; however, policy assessment is necessary to understand which policies are, or are not, cost effective in achieving nutrient load reductions. Achieving nutrient load reduction to water depends on the ability to effectively monitor policy outcome in pounds of nutrients reduced. However, there are many definitions, costs, and methods with which to monitor reductions.

This chapter contributes to research on analysis of nonpoint source policy and monitoring (transaction) costs of nonpoint source agricultural nutrient pollution. A comparative analysis of nonpoint source nutrient policies was conducted for Maryland, Pennsylvania, and Virginia with the goal of determining policy effectiveness, factors that influence policy output and, by proxy, outcomes (nutrient reductions to water).

Framework of analysis

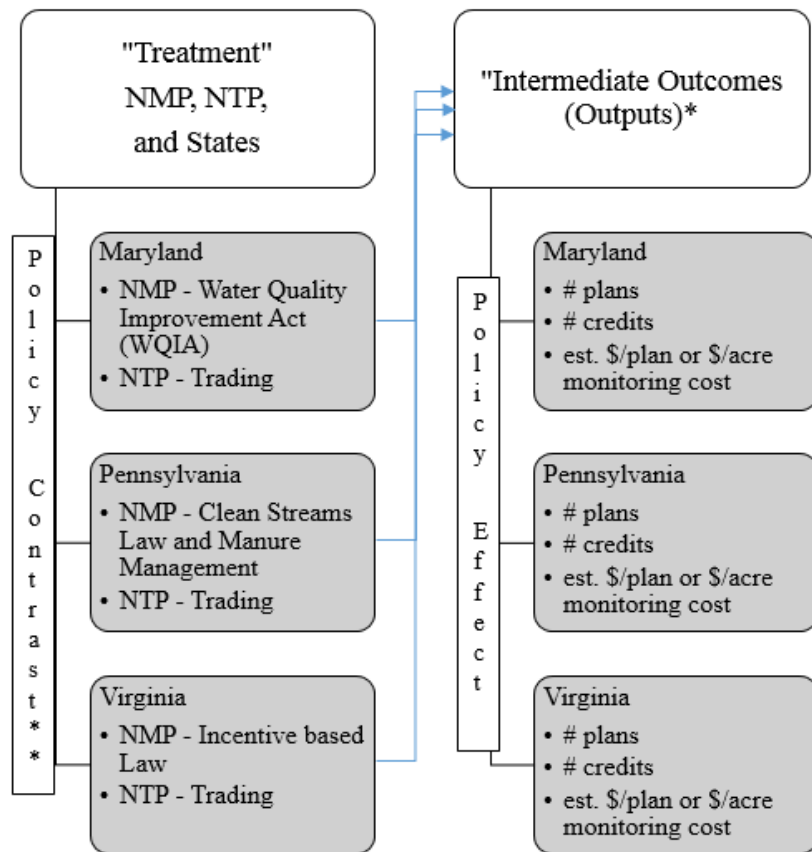
In other social policy research, policy outcomes are evaluated through determining treatment attributes that produce the outcomes. Weiss et. al. (2014), propose a framework, which is partially adapted herein. Weiss et. al., constructed a framework to “...determine why some programs are more effective than others and

what it might take to design and operate more successful programs” (2014, p. 779). Weiss et. al. suggest it is possible to determine average program effects for a group and variations in the program that relate to the program effects (2014). Weiss et. al. defines intermediate outcomes - such as rate of participation in an employment program, and target outcome – future earnings of participants (2014 p. 781). To compare two programs, the “...difference between average target outcomes for the two study groups is an estimate of the average effect of the program (labeled program effect)” (Weiss et. al., 2014, p. 781). The framework proposed in Weiss et. al. includes determining “proximal sources of variation in program effects” by comparing outcomes and working “upstream” to the program design and factors that cause variation in program effect (2014, p. 784). The social policy analysis method proposed by Weiss et al. can be adapted, in part, and applied to natural resource management policy as proposed herein (2014). The approach using concepts of “treatment contrast,” comparison of intermediate outcomes, and factors (or dimensions) to determine policy effect is described for “treatments” of nutrient management and trading as described below (Weiss et. al., 2014, p. 784).

Treatment contrast, output, and outcome

Designs of nutrient management and trading policy were compared as “treatments” in Maryland, Pennsylvania, and Virginia with the target outcome to reduce nutrients to the Chesapeake Bay. The policy designs were evaluated on four dimensions (different from Weiss et. al., 2014 dimensions) that describe potential policy variation that could affect target outcome: 1) voluntary or regulatory policy, 2) type of monitoring required in policy, 3) allowed participants (e.g. third parties), 4) main focus of entity with policy oversight (e.g. conservation or regulatory). This

analysis is a partial adaptation of Weiss et. al. because treatment contrasts of state and policy dimensions involve intermediate outcome (termed herein policy output) comparison (2014). The difference from Weiss et. al. in this step is that a counterfactual is not within the analysis because each state has some “treatment” or nutrient policy, therefore a counterfactual does not exist (2014). An adapted figure from Weiss et al. (2014, p. 785) is shown in Figure 1. In addition, measured outcomes of actual nutrient reductions are difficult to estimate for nutrient management planning. Measured outcome for nutrient management is based on current loads of thousands of farms all of which vary in reductions with nutrient management planning (Chesapeake Bay Foundation, Fact Sheet). Therefore, the intermediate output of number of plans recorded in the states is used as a proxy for nutrient reductions. Nutrient trading output is in pounds of nutrient reduced which is estimated by the Chesapeake Bay nutrient trading tool model (CBNTT), and other methods particular to each state. Because of uncertainties in modeling the nutrient credits reported can be considered an intermediate output as well. A policy outcome would be the actual, analytically measured nutrient reduction of the policies. Actual nutrient reduction is assumed by proxy through the intermediate outputs reported herein.



*Factors with potential to impact output:

- 1) voluntary/regulatory policy
- 2) type of monitoring required in policy
- 3) allowed participants (third parties)
- 4) main focus of entity with policy oversight (regulatory or conservation)

** Treatment contrast analysis is between states and between NMP and NTP policies.

Figure 1 Framework for nonpoint source agricultural nutrient policy analysis.

Monitoring costs are one dimension examined in this chapter because this cost is important not only to determine the differences in monitoring that can affect outcome, but also to determine how trading (as a “new” policy) changes - or shifts - the responsibility and costs of monitoring nutrient pollution. Monitoring cost falls

within a broader policy category of transaction costs. Further discussion of transaction cost in policy analysis is below.

Transaction Costs in Policy Analysis

The literature on transaction costs is broad and mostly qualitative in nature. Discussed below is a brief description of how transaction costs have been used in the past and in recent research literature.

Transaction costs occur in market exchanges and by extension have found application in analytical methods to assess policy effectiveness. Transaction costs in a market setting are organization, information, bargaining, managing, and rationing costs of private parties agreeing upon the terms of exchange for goods and services (Commons, 1931; Komesar, 1994). The costs described by Coase present one of the earliest discussions of transaction costs affecting a firm's choice to organize production (1937). Coase demonstrated how transaction cost accounting helped firms make "intra-market" choices between internalizing and contracting for certain production processes (Coase, 1937, pg. 107; Komesar, 1994). Coase also provided the basis for others to understand transaction costs in a legal and economic framework to explain the mechanics in the market failure of externality (Coase, 1960; Bromley, 1991).

Coase's, (1960s) recognition that markets likely do not operate in a "zero-transaction cost world," and that high transaction costs reduce economically efficient outcomes, has led to research to identify, understand, operationalize, and quantify these costs (Komesar, 1994, pg. 110). Solutions, then, to reduce transaction costs are important to improve market transaction efficiency. One method to improve efficiency is to clearly define and assign property rights; however, the efficiency of

this solution depends on costs of transaction being very low to nonexistent (Coase, 1960; Bromley, 1991). If rights are clearly assigned, then one party has the right and another party does not. Conflicts over resources or goods are settled when the parties bargain to gain mutual benefit. With zero transaction cost of bargaining (e.g. both parties having costless effort in gaining all appropriate information), the outcome maintains efficiency (Coase, 1960). Other proposed methods include employment of third party specialists (Demsetz, 1967) or clearinghouses (Woodward et al., 2002). Specialists in markets help reduce cost of transactions through improving access to information regarding the transactions or providing price transparency. Clearinghouses provide a space (physical or virtual) for parties to meet, exchange information, or obtain information for trade or bargaining.

Coase, and subsequently Bromley, Dahlman, and Komesar among others, recognized that market participation is determined by the costs of transacting, which is in-turn “...dominated by the cost of information” (Komesar, 1994, pg. 6; Coase, 1960; Bromley, 1991; Dahlman, 1979). Many transaction costs can fall under the broad category of the cost of information. McCann et al. outlined the problems of defining and measuring transaction costs for integration in policy analysis (2005). Transaction costs are viewed by some as wasted resources that impede transactions, however, quantifying their impact can help improve policy outcomes (McCann et al., 2005, pg. 528). McCann et al. (2005) and McCann and Easter (1999) conducted a literature review to define transaction costs in policy and constructed categories based on literature such as the costs of 1) exchanging goods or ownership titles; 2) organizing and participating in a market or government policy; 3) establishing and maintaining property rights; 4) gathering information, and 5) administrative costs in “resolution of

[an] externality” (McCann et al., 2005, pg.530; McCann and Easter 1999, pg. 404). In addition, McCann et al. described a boundary problem related to transaction cost measurement by questioning whether the cost of scientific research, social conflict in judiciary before policy enactment, or the enactment costs of the legislative bodies should be considered transaction costs (2005, pg. 531). Coggan et al. outlined a framework to measure the magnitude and potential influences on transaction cost to all parties (2010). Marshall extended previous schemes of transaction costs as static or dynamic to frame an adaptive analytical process for management of social-ecological systems and institutional choice (2013; Hanna, 1995; Challen, 2000).

In literature based on legal aspects of regulation, transaction costs have been assessed to determine fairness and effectiveness of water quality trading policy (Ruppert, 2004) and to comparatively determine which institutional process (judicial, legislative, or regulatory) “matches” an environmental problem by reducing costs of information (Elliott, 1984). In other analysis (including Chapter 2 herein), conflict resolution processes (institutions) have been assessed using transaction cost definition as the cost to obtain rights in environmental conflict (Duke and Csoboth, 2003).

In the case of environmental externalities in general, and nonpoint source agricultural nutrient pollution in particular, government intervention seeks to increase or protect the ecological structure of waterbodies through reducing nutrient excess. Normatively speaking, government intervention in natural resource conflict where rights are sought by environmental groups for natural resource protection should be structured to minimize, remove, or reduce the costs associated with externalities by optimally and efficiently selecting the policy to solve the problem (Faure and Skogh, 2003, pg. 10, 148-149; Bromley, 1991). However, all policies and institutional

processes have costs and are imperfect in different ways. State or government intervention is warranted in cases of market failure due to externalities (such as nutrient pollution) because of the failure of the market to provide efficient outcomes to all parties (i.e., farms apply excess nutrients that negatively impact water quality that, in turn, causes recreational users decrease in utility of the resource).

Methods and Data

Objectives of Analysis

A comparative analysis was conducted with a goal of assessing policy design factors that influence policy effects (Figure 1). Aspects of nutrient management and nutrient trading policy were evaluated from Maryland, Pennsylvania, and Virginia to determine if: 1) output of nutrient management policy (number of plans recorded) can be indicative of output (number of credits) in nutrient trading; 2) including nutrient management as a requirement to participate in nutrient trade influences the transaction cost of monitoring; 3) nutrient management policy design reduces or increases cost effectiveness of monitoring compared to nutrient trade; 4) there are key factors in policy design that influence outputs.

Steps for Analysis

Comparative policy analysis requires identifying the choices and design features that vary across the state policies, as well as the outputs and outcomes of those choices (Figure 1). The methods of comparative analysis can, or should, include selecting institutional arrangements where the problem in question has been adequately addressed to compare alternate institutional contexts (Mintrom, 2011).

The nonpoint source nutrient excess problem, arguably, has not been adequately addressed in any context as of yet.

In this case, the analysis considers two primary policy choices: 1) nutrient management planning/plans (NMP) as the status quo, and 2) nutrient trading program(s) (NTP) as an alternative. After briefly reviewing the policy choices, apparent design features (factors) that vary across policies are: 1) whether the policy is voluntary or mandatory; 2) whether the policy required monitoring, and of which type (defined further below); 3) who can participate in the policy (i.e. third parties); and 4) which branch of government has oversight of the policy, conservation focus or regulatory focus. The policy designs were compared using: 1) number of acres or plans in management for NMP and the number of credits for NTP; 2) costs estimates for NMP (cost per plan or per acre for NMP), and 3) qualitative analysis of the four policy design features. Costs for monitoring NTP were estimated as qualitatively higher or lower than NMP because the trading market is not developed. Monitoring costs in NTPs are relative to existing costs as the monitoring methods are similar in NMP. The monitoring costs and factors were then compared/contrasted within each state, across states, and between NMP and the NTP to assess the potential for key factors in policy design and monitoring cost effectiveness.

The number of nutrient management plans (output) is a proxy for nutrient reductions. It is estimated that the Chesapeake Bay model assigns reductions of 12.79% for nitrogen and 15.94% for phosphorous for acres in nutrient management (Blankenship, 2015). Actual pounds of reduction from a single plan are dependent upon physical characteristics of the field and current nutrient loads (see next chapter for field level heterogeneity). Therefore, outcome in pounds of nutrients reduced from

of nutrient management plans is not reported as part of this analysis. Number of credits, however, is indicative of modeled pounds of reduction. Yet, there is uncertainty as to the modeled and actual reduction, caution of over reliance on modeling complex systems, and recognition that models occasionally do not reflect actual Chesapeake Bay measurements (Boesch, 2006). This uncertainty is addressed by trading ratios where two pounds of nitrogen from a nonpoint source is required to compensate of one pound of nitrogen from a point source (Horan, 2001).

The policy design requirements and output information was acquired from online searches of available information from state (departments of environmental protection and conservation) and federal programs (U.S. EPA office of water), legal documents (statutes and regulation for nutrient management and trading) and press articles from the Chesapeake Bay media. Information on policy design (law, regulation, guidance) was gathered to compare the differing governance structures in the three states.

Definitions

Monitoring types

Monitoring was defined as rules within law, regulation, or guidance that govern the recording and reporting of policy output. Seven monitoring categories were defined and policy designs were mined for categories required. These categories are summarized below:

- 1) visual - observable practice (such as no-till or stream buffers)
- 2) administrative - unobservable practice, report or plan review such as nutrient management plan

- 3) modeled emissions - computer generated emissions
- 4) direct analytical - water/effluent/soil sampling
- 5) self-monitoring -self-reported
- 6) ambient - water quality data collected at stations within watersheds
- 7) volunteer - direct water quality sample collection

Nutrient management and trade monitoring requirements were grouped into the first five of the seven categories because ambient and volunteer monitoring requirements did not appear as part of the monitoring requirements in either NMP or NTP. The relative costs were assessed subjectively against the economic goal of cost effectiveness, that is, lower relative cost per unit output.

Trading terms

Trading programs in Maryland, Pennsylvania, and Virginia have been developed with U.S. EPA oversight and suggestions (U.S. EPA, 2003). The programs are similar in structure. Terms used for generating tradable credits are described below. The U.S. EPA evaluated each program in 2012 and provided feedback regarding program elements (U.S. EPA, 2012 a,b,c). Elements rated were policy provisions such as establishing eligibility of participants, baselines for sources, accountability, and tracking measures (U.S. EPA, 2012 a,b,c). Increasing importance has been placed on how the states design their programs to report, or monitor, nutrient reductions. The state's trading policy and rules contain similar requirements described as "certification," "verification," and "registration." Certification generally refers to pre-project approval of prior to implementation and includes checking baseline (these are different for each state and further described below) requirements and type of project proposed to produce credits. Verification is the monitoring portion of credit

generation including administrative or visual monitoring of nutrient management or other required plans and visual inspection of installed practices to meet baseline and practices that generate credits. Registration refers to the project being registered formally for credit exchange and is a post-project step. Virginia also uses terms of “qualification” and “authentication” (VADEQ, 2008). Qualification refers to a step where inspection and contract are developed for the credits and authentication is analogous to certification in the Maryland and Pennsylvania programs.

Status Quo

Comparative analysis requires that status quo be established as a basis for comparison of policies. States have a multitude of programs and policies to reduce nonpoint source nutrients such as cost-share, payment for ecological services, federal programs for land retirement, and best management practices. To confine the analysis, NMP was chosen as status quo because it is the one policy choice states have used with the farthest reach (in a property rights sense) into those entities defined as nonpoint agriculture (Blankenship, 2015). For example, as part of the concentrated animal feed operation (CAFO) permits as a point source under the NPDES permits, many farms are required to have plans for field and crop areas. As an extension, states like Maryland and Delaware have chosen to use a farm size threshold and require the plans for even non-CAFO farms. The farm size threshold is low in both states placing the majority of farms under the NMP laws. Therefore, out of any nonpoint source policy, NMP requirements have affected farms (arguably) more than other nonpoint source policies to date.

Cost Estimates

Costs of monitoring NMP were approximated from document-based searches for administrative and visual (site visit) requirements, number of dedicated staff, estimated salaries for the staff, and the departments responsible for monitoring (Table 1, Appendix A). The NMP costs were estimated in dollars per plan or dollars per acre under nutrient planning. Nutrient trading cost estimates were not calculated but an added level of “verification” was used to qualitatively assess trading monitoring requirements against nutrient planning monitoring costs (Table 2, Appendix B).

Summary of the Policy Design and Outputs

The next two sections briefly describe the results of information collected for NMP and NTP in the three states along with the monitoring requirements (see Tables 1-2). More detailed information in narrative form is in Appendices A (Nutrient Management Planning) and B (Nutrient Trading Programs).

Nutrient Management Planning

Maryland, Pennsylvania, and Virginia have implemented NMP differently - from enacting laws and regulations (Maryland), to non-monitored statutes and regulations (Pennsylvania), and incentive based programs (Virginia) (Table 1). Maryland’s statute requires NMP on all operations over a certain size, while Pennsylvania only requires manure management plans (slightly different than broader NMP) on all farms using manure. Virginia’s approach uses incentive based legislation and conservation policies where NMP are required to receive variance in 100-foot buffer requirements in Chesapeake Bay watersheds, cost share, or tax credits. Cost share is an arrangement between farmers and state or federal government to

implement approved practices (typically US Department of Agriculture) and receive funds to cover some or all of the cost.

Maryland and Virginia are similar in their monitoring requirements; both states institute administrative and visual monitoring for NMP. However, Virginia does not monitor in a regulatory sense like Maryland, and only monitors NMP in conjunction with other practices used for cost share, tax credits, or reduction of the 100-foot buffer requirement. Pennsylvania does not require submission of manure management plans or NMP. In Pennsylvania, monitoring does not occur proactively but reactively if a complaint is submitted to the Department of Environmental Protection (PADEP). Maryland's monitoring requirements are the strictest with plan submission to Maryland Department of Agriculture (MDA) required along with random audits of select farms.

Monitoring of NMP in Maryland and Virginia is largely on farm inspection, review of fertilizer receipts, and/or review of written nutrient plans. In Virginia, the conservation district staff do not only monitor plans but multiple practices. The costs were estimated based on the number of staff devoted to nutrient management, budget devoted to the program staff, and number of facilities under the staff review. The cost of monitoring NMP is accrued largely through expenditure on human resources. The data gathered was intended to generate an estimate of the cost of monitoring in human resource expenditure per plan or per acre under NMP. A survey of staff to detail how much time is dedicated to NMP audits and monitoring was not conducted as part of this study. However, a survey of this type would help refine and determine equality of employee effort across the study area.

Cost estimates in Pennsylvania were different than Maryland and Virginia because resources are not devoted monitor plan submission (because it is not required by law). The U.S. EPA's report on Pennsylvania's progress stated that tracking of plans was completely lacking (U.S. EPA Evaluation, 2014, pg. 1-3). Pennsylvania proposes to utilize conservation district staff (nutrient management technicians) to first educate and inform farmers regarding their responsibilities, not monitor and track plans. The cost in Table 1 for Pennsylvania is estimated as the cost for monitoring if conservation district staff were also required to monitor plans. (See Appendix A for complete description of monitoring requirements and cost estimates.)

The amount of acres in cropland in each state is listed in Table 1 to show a comparison of acres of cropland in each state. Comparatively, Pennsylvania is the largest state with 3.3 times cropland acres of Maryland and 1.5 times the cropland acres of Virginia (USDA NASS Census, 2012). There are 5.4 and 1.4 times as many farms in cropland in Pennsylvania as in Maryland and Virginia, respectively (USDA NASS Census, 2012). The average and median farm sizes are similar (average and median acreage, respectively): Maryland 166, 50; Pennsylvania 130, 68; Virginia 180, 72 (USDA NASS Census, 2012). The largest state, Pennsylvania, has the greatest amount of farms and acres in cropland, with Virginia second and Maryland third.

Table 1 Nutrient Management Planning and Nonpoint Sources (non-CAFO/AFO)

Policy Design		Monitoring Requirements	Estimated Monitoring Cost of Policy or Alternative
Maryland Statute/Regulation			
Water Quality Improvement Act (WQIA) Ann. Code of MD §8-801-8-807/ COMAR 15.20.04 - 15.20.08	Agricultural operations grossing over \$2,500 or greater than 8,000 live weight	<u>Administrative/Visual</u> Maryland Department of Agriculture (MDA) track Annual Implementation Reports (AIRs) and conduct on-site (visual) audits	Cropland^ 9,278 farms 1,396,144 acres 10 staff #, 5,426 plans 824,729 acres \$112/plan \$0.73/acre
Pennsylvania Statute*/Guidance			
Clean Streams Law (1937) Act 394 / PADEP Manure Management Plan (MMP) Guidance 361-0300-002	Agricultural operation (regardless of size) using land application of manure or agricultural process water	<u>Effectively no monitoring.</u> Pennsylvania Department of Environmental Protection (PADEP) will investigate if a complaint is submitted	Cropland^ 49,838 farms 4,546,052 acres 38 staff #, 1,791,660 acres (projected) \$0.55/acre**
Virginia Statute/Regulation/Conservation Policy			
State Water Control Law	No state-wide statutory requirements for nutrient management on nonpoint source agricultural operations	Virginia Department of Conservation and Recreation (VADCR) focus on education, no monitoring or enforcement	N/A

Table 1 cont. Nutrient Management Planning and Nonpoint Sources (non-CAFO/AFO)

Chesapeake Bay Preservation Act (1988)/ Chesapeake Bay Preservation Area Designation and Management Regulations (1989) 4VAC50-90	100 ft. buffer requirement on waterbodies, can be reduced with NMP and BMPs	<u>Administrative/Visual</u> Local municipalities enact ordinances and enforce buffer requirements and exceptions	N/A
Incentive-based Conservation Policy	Twenty best management practices require NMP to receive cost-share	<u>Administrative/Visual</u> VADCR Soil and Water Conservation District plan approval	Cropland^ 34,525 farms 2,990,561 acres 21 staff #, 786,000 acres \$.75/acre - \$1.31/acre (salary range for technician to specialist)
	State Income Tax Credit on Precision Nutrient & Pesticide Application Equipment. Six equipment categories require producer have NMP to receive credit	<u>Administrative/Visual</u> VADCR Soil and Water Conservation District plan approval	

#Salary range determined for nutrient management technicians from state salary search

*Pennsylvania's Act 38 does not mandate nutrient management plans for all operations, however some voluntary animal operations (VAO) have plans voluntarily.

** The monitoring of manure management plan (MMP) cost is estimated as a policy alternative of educating farmers to using staff resources to administratively monitor and track plans.

^Cropland data from USDA NASS Census 2012

Nutrient Trading

Nutrient trading policy is promoted in Maryland, Virginia, and Pennsylvania as a way for point sources to meet NPDES permit requirements in the future by purchasing credits or offsets from nonpoint agricultural sources. One credit is generally referred to as a unit of pollutant discharge mass per unit time below the baseline. The term offset is used in to identify credits that are used to “offset” new growth or future growth in an area that point source treatment plants are required to manage by purchasing credits or other technological means. All three states allow offsets as well as credit purchases. The U.S. EPA anticipates that allowing credit purchases will be cost-effective for point sources. Limited research shows point sources have high abatement costs compared to nonpoint source agriculture (Van Houtven et. al., 2012). In theory, the facilities with higher abatement costs would purchase lower cost abatement to meet permit requirements.

The three states have developed trading programs with similarities and differences (Table 2). Maryland’s program was implemented under an existing statute of the Water Quality Improvement Act. Guidance documents from Maryland Department of Environment (MDE) and MDA provide policy procedures for entities interested in trade. Pennsylvania and Virginia also implemented their trading programs under existing statutes. However, Pennsylvania sets forth regulations for trade, while Virginia instituted a watershed general permit for sources. All three states allow trades between point sources (point source to point source) and point source and nonpoint sources for nitrogen, phosphorous, and sediment on a mass per time (pounds per year) basis. All three states also allow involvement of third parties such as aggregators or brokers to facilitate trade. Aggregators accumulate and sell credits,

assuming all liability for trade. Brokers work to put credit demanders with credit suppliers and do not necessarily assume liability.

The states set different eligibility requirements (baselines) for the sources to enter the market. Only Maryland requires farms meet a specific modeled load (lbs./acre/year) using an online interface nutrient trading tool (CBNTT). These modeled loads are based on the TMDL allocations for nonpoint sources. Maryland baseline also includes plans as required by law, nutrient management and/or soil and water conservation, be in place before entering the market (MDA 2008). Pennsylvania requires plans (either nutrient or manure management as applicable under current law) and installation of one additional practice as applicable: buffers, manure application setback, or 20% nutrient application reduction. Virginia's baseline requires plans applicable by law, cover crops, fencing of livestock, and vegetative buffers on waterways as applicable.

All three states require additional monitoring as part of the nutrient trade but rules allowing third party involvement are an attempt to lower the costs. This additional visual and administrative monitoring, translated as an increase in monitoring cost, is shown in Table 2 in the verification column. The increased costs are due to the steps necessary to validate credits that are not necessary in status quo. Maryland policy also states that direct analytical monitoring may be required if deemed necessary.

All states allow third parties to participate in generating and selling credits, this may be in the form of brokering or aggregating credits. Clearinghouses are also allowed in Pennsylvania and Virginia and exchange format is allowed in Maryland and Pennsylvania. These formats for market structure increase available information

to buyers and sellers to facilitate and improve trade interaction (Woodward et. al., 2002). Bilateral (direct) negotiation is also allowed in all three states between buyers and sellers. Woodward et. al. discusses these different market structures and assign relative transaction cost of initiation and trade as low or high (2002). Bilateral agreements have the highest transaction cost, but lowest initial cost because the information, contract, and enforcement costs of individual negotiation and bargaining for goods can be high compared to other market structures (Woodward et al., 2002). In comparison, exchange and clearinghouse formats reduce transaction costs though they may have higher initial costs of establishment than a bilateral structure (Woodward et al., 2002). Briefly, exchanges create uniformity and equivalency of goods (that may not be completely uniform to begin with) and provide transparency in price and easily accessible information to participants (Woodward et al., 2002). Clearinghouses remove all links (regulatory and contractual) between buyers and sellers and the clearinghouse purchases from sellers then sells to the buyers and creates uniformity and stable prices through aggregation (Woodward et al., 2002). The clearinghouse can also, if permitted by law, assume liability for the trade (Woodward et al., 2002).

Table 2 Nutrient Trading Programs Design and Monitoring Requirements

Policy Choice for Nonpoint source (NPS)		Monitoring Requirements	Verification/ third party participation
Maryland /guidance under amendment of existing statute			
Water Quality Improvement Act (WQIA) Annotated Code of MD §8-901-8-904		Statute establishes voluntary agricultural nutrient trading program	None in statute.
Nutrient trading MDE Policy and Guidance	MDE responsible for decisions regarding trading eligibility, credit certification, verification, compliance monitoring and enforcement	Administrative /visual/ direct monitoring authority	Visual and direct monitoring
Nutrient trading MDA Policy and Guidance	Baseline: soil and water conservation plan, nutrient management plan, and current modeled load meets TMDL for N and P in lbs./acre/year	Administrative, visual (buffers and fencing), and modeled monitoring. Contract requires allowing onsite inspection	Administrative/ Visual/Direct monitoring. Third parties and/or MDA twice per year and annual onsite inspections depending on BMP <i>Trading platform established*</i>

Table 2 cont. Nutrient Trading Programs Design and Monitoring Requirements

Pennsylvania/regulation under existing statute

Rule promulgated under existing sections in the Clean Streams Law as amended (1937) Act 394. PADEP regulation Env. Quality Board 25 PA Code Chapter 96 Water Quality Standards Implementation	Baseline: nutrient and manure management and erosion and sediment control plans (if required). NPS also has to meet 100-ft manure application setback, 35ft. buffer, or reduce nutrient application by 20 percent	PADEP Verification plan with self or third party administrative and/or visual inspection	Administrative/visual monitoring by PADEP. In addition to self or third party, NPS must allow PADEP to randomly inspect farm <i>Third parties established**</i>
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Virginia/regulation (general permit) under amendment of existing statute

Waters of the State Ports and Harbors Title 62.1 § § 62.1-44.19:12 through 62.1-44.19:19. VADEQ regulation General watershed permit 9 VAC 25-820-10 et seq. "Watershed GP"	Baseline as applicable: soil conservation plan, nutrient management plan, cereal cover crops, fencing excluding livestock, vegetative buffers	Administrative and visual monitoring. NPS must use third party public or private entity to verify and sell offsets. VANPS Trading Manual lists "authentication" as records of nutrient application, photographs of buffers and livestock exclusion, and plant/kill dates of early cover crops	Visual monitoring. Watershed GP authorizes inspection of NPS offsets allows onsite visual inspection by point source representative, VADEQ, and aggregator <i>Third parties established**</i>
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*An online trading platform (Nutrient Trading Tool) has been established where sources can locate one-another.

**Third party establishment had the potential to lower monitoring costs (Woodward et al., 2002).

Comparative Policy Analysis

This analysis compared NTP and NMP in Maryland, Pennsylvania and Virginia by using factors within policy design to determine effect on output and monitoring cost effectiveness of agricultural nonpoint source policies. Objectives were to determine if: 1) output of nutrient management policy (number of plans recorded) can be indicative of output (number of credits) in nutrient trading; 2) including nutrient management as a requirement to participate in nutrient trade influences the transaction cost of monitoring; 3) nutrient management policy design reduces or increases cost effectiveness of monitoring compared to nutrient trade; 4) there are key factors in policy design that influence outputs. Factors included: 1) whether the policy is voluntary or mandatory; 2) whether the policy including required monitoring, and of which type; 3) who participates in the policy (e.g., third party); and 4) the focus of the government agency with oversight of the policy.

Policy Contrast: Intra-state Comparison

The first and second research objectives were to determine if outputs of NMP would be indicative of outputs in NTP. The second objective was to determine how monitoring costs changed with the addition of NTP. The participation factor, listed in Table 3 as outputs, is dependent on monitoring and policy design. Therefore, factors that can be elicited from policy design may provide insight to output. Data were gathered from multiple state and federal reports and websites.

Table 3 Comparative Analysis Results

State	Policy	Policy Design	Policy Administration	Output
Maryland	Nutrient Management	Statute/Regulatory	MDA	5350 plans (98% of farms under regulation)#
Maryland	Nutrient Trading	Incentive/voluntary	MDA/MDE	No trades, no credits generated
Pennsylvania	Manure Management	Statute/Complaint-driven regulation	PADEP Bureau of Conservation and Recreation	717 plans (~2.5% of 27,875 AO farms have plans)*
	Nutrient Management	No regulation/incentive	PADEP Bureau of Point and Nonpoint Source Management	1,189 voluntary plans (4% VAO have plans)*
	Nutrient Trading	Incentive/Voluntary	PADEP Bureau of Point and Nonpoint Source Management	NPS Credits (2014) TN 299,859 certified and 106,030 verified TP 253 certified and 0 verified
Virginia	Nutrient Management	Incentive/cost-share/tax-credit	VADCR	Estimated 97 (16% of unpermitted farms with livestock 2% of all farms including regulated farms have plans) +
	Nutrient Trading	Incentive/voluntary	VADCR/VADEQ	NPS registered credits (Oct. 2015) ++ N 4,688 P 1,221

Notes for Table 3:

#MDA Nutrient Management Program 2014 Annual Report

(http://mda.maryland.gov/resource_conservation/counties/MDANMPAnnual2014.pdf)

*USEPA Region 3 Pennsylvania Animal Agriculture Program Assessment

(http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/agriculture/PennsylvaniaAnimalAgricultureProgramAssessment.pdf)

**PADEP Bureau of Point and Non-Point Source Management. Nutrient Trading Nutrient Credit Registry.

(http://files.dep.state.pa.us/Water/BNPNSM/NutrientTrading/NutrientCreditRegistry/Summary_Table_of_Results_2014.pdf)

+ USEPA Region 3 Virginia Animal Agriculture Program Assessment

(http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/agriculture/VirginiaAnimalAgricultureProgramAssessment.pdf)

++Virginia Department Environmental Protection. Virginia Nonpoint Source Nutrient Credit Registry.

(<http://www.deq.virginia.gov/Portals/0/DEQ/Water/PollutionDischargeElimination/NonpointCreditRegistry.pdf>)

Russ Baxter VA DEQ (<http://www.slideshare.net/CleanH2O/the-use-of-nutrient-credits-in-virginia>)

Maryland

Maryland's law and regulations for NMP require most agricultural operations to have plans; therefore, the highest participation is in the Maryland program.

However, to date, no credits have been generated in the nutrient credit registry (personal communication Susan Payne, April 24, 2015). With statute requiring the agricultural operations to prepare and implement nutrient management plans,

Maryland reports that they are well above their 2015 milestone goal (MDA Chesapeake Bay TMDL/WIP). Maryland reports they are at 199% of their 2015 milestone - 369,789 current acres with 185,666.35 acres as their 2015 goal. More acres (598,245.45) are planned to accomplish the targeted 2025 goal for nutrient management planning and compliance with their WIP Phase II (MDE WIP II 2012). As shown in Table 1, the cost of monitoring is approximately \$112/plan or \$0.73 per acre.

There are several changes from NMP with the addition of NTP. The first is that the MDE is part of NTP monitoring and administration. In addition, the MDA and/or third parties are required, and the third parties may be contracted, to conduct monitoring of credit generation and verification (MDE, 2008 a,b). The policy in Maryland not only requires the nonpoint agricultural entity be subject to modeled monitoring of current and future loads through the online CBNTT, but also requires annual to twice per year onsite inspections to validate applicable plans and practices (MDE, 2008 a,b). The onsite inspection is to verify that appropriate buffers and setbacks are in place and that the BMP(s) generating the credit(s) is/are installed and maintained. These monitoring requirements for NTP are, not only in addition to - but well above - the monitoring requirements for the NMP policy. The validation step supports the assumption that monitoring cost will be higher, and that existing NMP may slightly lower the cost in NTP if the farmer has been diligent in prior NMP submission.

To reduce monitoring costs, Maryland allows the use of aggregators, brokers, or third parties to facilitate nutrient trades. Although no nutrient credit transactions have occurred in Maryland, 200 farms have been evaluated (Wheeler, 2014). Maryland does not appear to have third parties, such as private companies, that have established presence and are interested in nutrient aggregation or brokering. One possible reason for the lack of third parties is that the MDE Nonpoint Source Management Plan states that trading policy is in continued revision to align with growth policy documents (MDE NPS, 2015-2019). In addition, the web-based marketplace is “under construction” and has undergone multiple revisions (Maryland Nutrient Trading Program). This uncertainty may discourage the private third parties,

who have the potential to decrease monitoring costs, from establishing business presence. An Ag Brief from MDA encourages farmers to contact the Soil and Conservation District if they are interested in trading (MDA Nutrient Trading Program, 2015). However, directing farmers to simply contact the conservation district does not indicate a full path to implementing a trade (i.e. finding a credit purchaser) and only facilitates the farmer installing a BMP. Aggregators and brokers would be in a different position to assist farmers with producing credits than the conservation district employees.

Pennsylvania

Pennsylvania's nutrient management policy leaves a large portion (approximately half the operations statewide) of crop agriculture not required by law to have nutrient or manure management plans (Brubaker and Schneider, 2009). Pennsylvania plans are tracked voluntarily for some animal operations but amount to a very small percentage of overall operations. The operations that are required to have manure management plans may not even be aware of the requirement (Brown, 2014). Based on the estimates provided in Table 1, if all of the farms that were required to have the manure management plans were tracked the cost may be approximately \$0.55 per acre. The cost per plan was not estimated because the number of farms required was not available in the data search.

Pennsylvania reports the largest amount of available nitrogen credits (but no phosphorous credits) for trading of the three states; yet, there is no available evidence that monitoring and tracking of the most basic plans necessary for nutrient or manure management is performed. The change to trading policy requires that farms may need to implement up to three new plans and/or practices to meet baseline (assuming the

farms are unaware of regulatory requirements), which also requires verification by the farmer (self) or a third party. Monitoring of the baseline for trading and BMP installation is visual and administrative inspection of the farm, plan, and practice implementation. In addition, the farmer must - by regulation - allow PADEP on-site to inspect the farm and practices. This monitoring change from NMP to NTP for the nonpoint source agriculture includes dramatically increased monitoring by third parties and PADEP. Therefore, the change from essentially no monitoring to the monitoring requirements in NTP will increase costs.

An alternate view of NTP in Pennsylvania, based on the highest NTP participation of nonpoint sources of the three states, may indicate that trading has lower barriers (potentially in cost) to entry, certification, and verification. Pennsylvania lists approximately 2.5% of the animal operations and 4% of the voluntary farms have NMP and 106,030 nitrogen credits have been verified (last step in credit generating process, PADEP Credit Generation). There are no phosphorous credits verified but 253 have been certified (PADEP Credit Generation). One factor that may influence NTP participation is that monitoring stays within PADEP but changes bureaus: from the Bureau of Conservation and Recreation for NMP to the Bureau of Point and Nonpoint Source Management for NTP. The department of agriculture is not part of the process. A second factor may be that Pennsylvania has active brokers and aggregators generating credits as well as a clearinghouse (PENNVEST). However, the clearinghouse provides auctions and has auctioned point source to point source trades.

Pennsylvania has recently been instructed by U.S EPA to correct deficiencies in their threshold and baseline requirements and has stated they will not approve

credits used in NPDES permits until Pennsylvania ensures consistency with the TMDL (PADEP Phase 2 Watershed Implementation Plan, 2015). Pennsylvania is in the process of changing the credit certification process and requiring a 3:1 trading ratio for agricultural nonpoint sources and is also considering a performance based baseline similar to Maryland (PADEP Phase 2 Watershed Implementation Plan, 2015, pg. 8).

The most important monitoring cost implication of Pennsylvania's policies is that manure management plans are required for animal operations but not currently tracked. To trade and create a large supply of nonpoint source credits, the manure management plans are assumedly tracked in the current supply of credits. In addition, other baseline requirements of choosing a setback, buffer, or nutrient application reduction are also assumedly tracked. Because Pennsylvania does have third party entities generating trades, there is indication that monitoring costs may be lower in a trading scheme compared to the current situation if the farmers are incentivized to also implement new practices, submit plans, and provide additional abatement through use of third parties.

In sum, the current policy of non-monitored nutrient and manure management policies has not appeared to impact the participation of generating credits for nutrient trading. Pennsylvania has third parties and public forums such as PENNVEST facilitating trades. The policy change of stricter regulation (required plan submission for all regulated sources) or increased monitoring may possibly take resources from educating the farmers about the existing regulations.

Virginia

Virginia reports robust NTP and NMP participation, including nonpoint source credits available through third parties. Virginia is slightly more complex in the

administration of voluntary NMP and its programs are strongly incentive-based. Approximately 16% of unpermitted farms with livestock have NMP (Table 1). The cost-shared tax credit based policy has apparently been effective in encouraging farmers to have nutrient management plans. The NMP are required for reducing buffer requirements in the Chesapeake Bay watersheds, tax credits for such items as equipment, and cost share. The method of monitoring is administrative and visual monitoring, and the local entities (such as the soil and water conservation districts) monitor the installation of best management practices and document the NMP. Virginia Nutrient Credit Exchange Association reports: “Most of the reported reductions were achieved through nutrient management planning for farms...DCR recruited and trained more plan writers, who were connected with farmers through Virginia's Soil and Water Conservation Districts.” (VNCEA News release, 2014) and in 2014 Virginia reported 786,000 acres under NMP (VADEQ 2014). The estimated cost of monitoring in Virginia is similar to the other states at \$0.75-\$1.31 per acre (depending upon the salary levels from technician to specialist) which were both mentioned in Virginia’s policies.

The addition of NTP in Virginia involves similar monitoring requirement changes compared to Maryland and Pennsylvania. Virginia has the second highest verified and registered participation in NTP, with 4,688 nitrogen and 1,221 phosphorous credits available for trade (Virginia’s nonpoint source nutrient credit registry, October 2015). Verification by third parties and VADEQ is required for baseline and BMP installation. Credit purchasers are specifically allowed to inspect the nonpoint source credit generator as well. Some nonpoint source agricultural operations are currently not monitored (for example, if they have a 100-foot buffer on

watercourses present and do not receive cost share or tax credits for equipment) and NTP requires a shift to additional monitoring requirements of NMP and BMPs by outside entities (aggregator, VADEQ, credit buyer). Virginia limits available practices to trade to visually verifiable practices (e.g., continuous no-till, land conversion, cover crop planting dates) that could improve monitoring cost effectiveness by creating consistency for a small set of practices. However, limiting practices may also inhibit cost effectiveness of credit trading because the available BMP choices may not be the lowest cost for the individual farmer. Nevertheless, it is evident that some barriers are reduced in Virginia evidenced by participation in NTP.

Resource Management Plans (RMP), which are proposed as voluntary regulation, are worth mentioning in that their implementation by farmers in the Chesapeake Bay will require nutrient management plans. Again these plans are voluntary regulation, the farmers will “opt –in” and by complying with regulations in the plan will be “...assured that he or she is in compliance with any new state nutrient, sediment and water quality standards; in particular, regulations related to the Chesapeake Bay and all local stream segment TMDLs” (VADCR). These plans will have local level administration, support, and reporting and are proposed to incentivize and engage farmers in a very different manner than a traditional regulation based approach. The U.S. EPA reports that “...overwhelming signups for RMPs and stream fencing demonstrate that the agriculture community is ‘stepping up’ the pace of implementation” (Chesapeake Bay Commission Meeting, 2015, P. 4).

In sum, Virginia has reported strong nonpoint source NMP participation and has the second most activity (with verified credits) in NTP of the three states. The monitoring in Virginia is conducted by local entities that have a cooperative (rather

than regulation driven) relationship with the farmers. In addition, a small set of BMPs are allowed for trade and are verified by third parties. The small set of BMPs monitored by local entities, and involvement by third parties, has the potential to reduce the cost of adding the NTP compared to other states. The current incentive-based approach is more cooperative and may facilitate policy changes that are also incentive-based, like trading.

Policy Contrast: Inter-state Comparison

An inter-state comparison was conducted to address research objectives two three and four: does including NMP as a requirement for NTP reduce monitoring costs, is there evidence that one policy alone is more cost effective than the other, and are there key factors of the four factors in the analysis? Government agencies anticipate that nutrient trading will be more cost effective than the other options for nutrient reduction. This inter-state comparison was conducted to determine if one state has designed policy to improve outcomes and/or lower the cost of monitoring for nutrient trading compared to nutrient management planning.

Design of individual policies occurs within the state's institutional context and with this analysis the context becomes important to the output and eventual outcome. Maryland, Pennsylvania, and Virginia state NMP requirements have very different designs, implementation, and subsequent monitoring of output. The NMP differences offer different implications for the addition of NTP. Maryland currently has the most stringent and broadest nutrient management law, which is a wide-ranging regulation for nonpoint source agricultural nutrient sources and potential pollution reduction. Their regulatory approach requires tracking of nutrient management plans; therefore, it can be said that the policy design is driving the output. Pennsylvania, comparatively,

has regulation for nonpoint source agricultural nutrient pollution, but effectively does not monitor manure management plans and monitors very few voluntary nutrient management plans. Again, reporting the output as number of plans is reporting the policy output as designed. The indication that farmers may not be aware of the regulation leads to the conclusion, many farmers do not have the plans and therefore would be more likely to have increased nutrient use compared to Maryland. Virginia takes a different approach and, compared to Maryland, a regulation-based nonpoint source agricultural NMP is lacking. However, Virginia's approach is incentive-based and has gained participation that has produced the most reported reductions in the state.

By comparing all three states' NMP design, differences in factors became apparent as well as and potential for different outcomes. Collecting data on quantitative monitoring output (number of plans) does demonstrate potential connection between policy design and outcomes (i.e., eventual nutrient reductions). Aggregate participation in Virginia cost-share indicates the nutrient plans and not being prepared just because they are required (as in Maryland) that farmers are also implementing *additional* practices. Therefore, Virginia's policy design for NMP can be considered the most likely of the three states to potentially affect reductions. In addition, Virginia's design has the potential to reduce the cost of monitoring in NTP because of the compatibility of the incentive-based policies, presence of third parties, and limited BMPs to monitor for NTP.

Comparatively, Maryland does not have any documented nutrient credits generated whereas Pennsylvania and Virginia report active credit generation. Maryland established their mechanism for trade in the CBNTT platform and has

continued to adjust the NTP which may be the reason credit generation is not active. In addition, Maryland has instituted a tax (MDE Bay Restoration Fund), which will fund treatment plant upgrades and impact NTP demand from point sources. Pennsylvania has active third parties that are generating nutrient credits. Recently credits in PENNVEST auctions have not had buyers, which may indicate additional problems with the Pennsylvania market (Markit Financial Information Services). Research and surveys would need to be conducted to determine the exact cause lacking credit purchase. One possibility is the cost of credits is low and the supply is high relative to demand (Markit employee personal communication, March, 2016). In comparison, Virginia trading policy requires third parties to register trades. Virginia's trading program is labeled a model program by federal agencies (USDA Press Release, 2014). These results indicate that two factors may have the most influence on monitoring cost and policy output: incentive-based program compatibility and third party participation.

The importance of institutional context indicated by this analysis is that an incentive based, voluntary policy may be best supported by an existing incentive based policy. In addition, the analysis indicates there are factors within a regulatory policy design that may hinder trade. Virginia's reported outputs of NMP and NTP indicate both policies have had success compared to Maryland and Pennsylvania's outputs. In contrast Pennsylvania's lack of monitoring in manure management and lack of participation in voluntary nutrient management plans indicates possible weakness in the current policy which may hinder the addition of NTP. However, Pennsylvania reports the most active credit registry of the three states by numbers, and this could indicate that the costs of trading, including the cost of monitoring, has been reduced

through active third parties. Lastly Maryland's stringent regulatory regime, lack of participation by third parties, and reduced demand from point sources because of the Bay Restoration Fund may be inferred to hinder trading. The continued involvement and realignment of policies within the MDA and MDE may create distrust or uncertainty that has hindered the generation of credits and the establishment of third parties that would have the potential to reduce future costs of trade. In conclusion, strong reported participation in NMP in a regulatory regime may hinder participation in the trading market. In addition, the cost of monitoring the two policies in Virginia may be lower because the nutrient management plan is *already part of the process* that farmers use for other incentive based programs and practices like cost share. The addition of trading would appear to have the overall lowest cost of monitoring in Virginia. However, if the farms participating in trade have already implemented many BMPs (good stewards) the reductions available for trade may also be low.

The comparison in the sections above analyzed the inter- and intra-state policies that have the potential to improve monitoring cost effectiveness and outcomes (pounds reduced) for nonpoint source nutrient pollution reduction. The final results section below compares the policies of NMP and NTP to determine if one policy has a better potential to reduce monitoring costs and provide best outcome for nutrient reduction.

Policy Contrast: Nutrient Management and Nutrient Trading, Including Alternatives Analysis

This section focuses on the fourth research objective: is there a key factor that indicates NMP, NTP, or one state exhibits the best capacity to reduce monitoring costs?

Policy design of NMP can be monitored at a low cost per acre, and the addition of NTP will add to this cost. The cost effectiveness of these monitoring choices (administrative, visual) for NMP is assumed to be low compared to other monitoring choices, such as modeled, direct, and ambient (which may be higher due to technical equipment costs required for modeled, direct and ambient). Administrative and visual costs may be higher than others such as self and volunteer monitoring because staff time would be reduced with others who voluntarily conduct the monitoring. However, the costs of modeled, direct, ambient, self, and volunteer monitoring were not estimated in this analysis (for definitions see Methods section). Any change in policy for NMP would possibly take from existing resources allocated and if resources are reallocated then it should be to improve monitoring outcomes of nutrient reduction. The addition of NTP should be designed to lower costs and improve outcomes. Virginia, as assessed, had the best outputs and the lowest potential monitoring costs in nutrient trading. If NTP in Virginia also reduces more nutrients over time at a lower overall monitoring cost than NMP alone, then the Virginia NTP policy design has the greatest capacity to reduce nonpoint source nutrients.

One way to determine if one policy increases capacity better relative to the other policy is to provide alternatives analysis that determine tradeoffs associated with the policy changing. That is, how the policy could be improved and what resources would be affected. If the cost of monitoring is the only cost compared, then there is potential to determine if the policy may improve outputs for other states. Some alternatives considered are discussed below.

Alternatives Analysis

Maryland Alternate Policies

As an alternative policy to NMP as currently administered, Maryland could concentrate on nutrient management violations. Maryland could increase audits from the past number conducted and monitoring costs would also increase but compliance with the law would be more certain. Nutrient management compliance audits revealed approximately 25% of farms in Maryland are estimated to have major nutrient management plan violations, and the biggest concern are the estimated 6% may be over applying fertilizer: “Assuming that the audited farms were representative of the total regulated farm operators, there could be 1,350 farms, 25.0% of the total, with major violations. However, MDA notes that based on its audits, it is estimated that there are only about 6.0%, or 323, of the 5,382 farm operators who are over applying fertilizer – the biggest noncompliance concern” (MDA Operating Budget Data, 2015 pg. 8). It appears Maryland may increase audits based on audits increasing in past years (MDA Report to Governor, 2014). If it is assumed that no additional staff is needed to increase monitoring and compliance, which the existing staff could focus on the violations, and that improving the plans on farms with violations actually results in reducing excess nutrients then the policy change is beneficial because improved reductions result while costs remain unchanged.

Increased NMP stringency is another policy option. The statewide summary for Agricultural Phase II WIP lists enhanced nutrient management as a goal (MDE WIP II 2012). Enhanced nutrient management includes using the phosphorous management tool, however, implementation of using this tool has stalled due to opposition from the farm community (Bond, 2015; Maryland Farm Bureau, 2013).

Therefore, it is unclear at this time how the policy change to enhanced nutrient management would be monitored.

Pennsylvania Alternate Policies

Other alternatives to current nonpoint source agriculture nutrient management policy in Pennsylvania could be, at the very least, require submission of manure management plans to the PADCR, or the PADEP. There are indications that the U.S. EPA will require PADEP to better track manure management plans in the future (U.S. EPA Pennsylvania milestones, 2014-2015). In addition, policy change could be to institute a further reaching nutrient management law similar to Maryland.

Implementation of both of these policies increase overall transaction costs. The transaction costs from current policy would be legislative change, information, and mobilization in addition to costs of monitoring. Introducing new legislation has costs beyond cost of monitoring for parties to demand change in nutrient policy.

Reallocation of resources for policies of manure and nutrient management would include increased enforcement, changes in regulation or statute requiring plan submission, and monitoring of plans. Based on the results from Virginia it is unclear if increased regulation would improve outcomes in Pennsylvania. Pennsylvania could continue education and include incentive based and cost share that requires plans.

Based on results in Virginia, Pennsylvania may benefit from instituting wider-spread incentive based programs that stack NMP as a requirement for cost-share with other practices.

Virginia Alternate Policies

Virginia's policy for nonpoint sources is incentive based, and monitored by local entities (counties and local soil and water conservation districts). Incentive based policies mean that the farmer is willing to be monitored and submits the information necessary to track their activities. In comparison to a regulatory based policy design, the potential "self-monitoring" in an incentive-based program would likely reduce monitoring costs and costs of compliance because the farmer is a willing party. Increasing regulation for NMP in Virginia has tradeoffs to consider in that resources to administer cost-share may be impacted. In Virginia, it is not apparent that more regulation would have better output than the current incentive based output. As stated above, the cost-share and tax programs are obtaining the NMP in addition to other practices that could reduce nutrients. Therefore, monitoring costs in Virginia NMP, have the potential to be lowest in incentive based policy settings with the potential to have nutrient reductions beyond just the plan.

As detailed above, monitoring costs inevitably increase for farmers, point sources, and government with the addition of a nutrient trading policy, however Virginia may display the best capacity for improving outcomes with both policies than the other states. In Virginia, monitoring cost savings likely comes as part of the incentive-based policy design: the *local entity* with *non-regulatory* farmer relationship is responsible for monitoring and is able to not only monitor plans, *but the additional practices* that are implemented. This "stacking" of monitoring effort has the potential to lower monitoring cost of not only the plans but the other best management practices as well-including nutrient trade. The designs of the nutrient trading programs across the three states are similar with administrative and visual monitoring that increase with trading. The differences are that Pennsylvania and Virginia currently have active third

parties that have the potential to reduce monitoring costs for the parties including the government. The two states that appear to have the most developed third party participation (Pennsylvania and Virginia) also have the most credit generating activity. Virginia also constrains BMP choices to four while Maryland and Pennsylvania have eight or more choices (see Appendix B). Fewer BMP choices are available to trade which may lower monitoring requirement by improving consistency verification of practice and improving possibility of “true” verification. The tradeoff of limiting farmer choice, however, is the potential reduction in overall cost effectiveness and because the farmer may be unable to choose any practice that is the lowest cost for the operation that also generate the most credits.

Implications

The problem of monitoring and enforcement plague all instruments of agricultural nonpoint source policy, and new policies should increase capacity to address problems in existing policy. This analysis frames the problems of monitoring as an institutional choice and provides insight to the perceived potential for trading to reduce monitoring costs. There are several implications drawn from the analysis. The first implication is that the transaction cost of monitoring will inhibit the nutrient credit trading market as a whole. The farmers that have the highest amount of current pollution (termed “poor stewards”) in the current regime likely do not participate in any nutrient reduction programs voluntarily and would not qualify to trade under any of the baseline scenarios (because they do not implement any plans, buffers, or other measures ex-ante). “Farms that have done the least may have the least incentive to enter the market, since the ability to recoup costs of implementing multiple practices may be highly uncertain” (Wainger, 2012, pg. 9262). Adding increased monitoring

requirements (as all state trading polices do) where, point sources, third parties and the state are required to inspect their property and operations is a transaction cost and disincentive to these farmers to participate in trading. In the most stringent state, Maryland, the nonpoint source farmers that are subject to the nutrient management law only have to submit paper records each year and have potential for an on-site audit. With trading, Maryland farmers face a certain on-site inspection potentially more than one time per year. “Many farmers have a historic mistrust of regulators, or they may worry that the monitoring required for participation in water quality trading is a step toward full incorporation in the regulatory structure; thus is may be necessary to work through trusted third parties...” (Fisher-Vanden and Olmstead, 2013, pg. 166). Therefore, increased monitoring burden not only for the government resources, but also the farmer and should be adequately addressed in any trading policy.

Second, while all trading programs have increased monitoring requirements beyond nutrient management policy alone, including requirement of modeled load in baseline (as Maryland does) may complicate trading contracts more than monitoring criteria that does not require this step (currently Pennsylvania and Virginia). Administrative and visual monitoring methods are currently used for NMP. Trading policy in Maryland, on the other hand, includes the modeled monitoring (via CBNTT) to estimate a farmer’s nutrient levels. Including a modeled nutrient monitoring requirement has the potential to inhibit contract ease by holding the nonpoint source to a numerical standard or cap of sorts similar to point sources. This reported nutrient level is a condition of the nutrient credit trade and may provide additional avenues for point source liability (Fisher-Vanden and Olmstead, 2013). Under all of the state’s trading policies the liability of trades is currently placed with the (NPDES) permit

holder. "...liability for nonperformance or ineffectiveness lies with point-source credit buyers. Some attribute low trading volumes in current water quality trading programs to this problematic assignment of liability...EPA can only impose penalties on permitted point sources through the National Pollutant Discharge Elimination System" (Fisher-Vanden and Olmstead, 2013, pg. 161). Essentially, in the Maryland policy criteria, the nonpoint source becomes a point source via reporting a baseline load that may be placed in a legal contract with the NPDES permit holder, however, only the NPDES permit holder is liable and able to be directly monitored. The costs of monitoring the nonpoint source then would be borne by the point source in the trade agreement because it is in the point source's best interest to ensure the nonpoint source is in compliance. Trading policy allows the point source to take this role in place of, or in tandem with, the regulator. The liability of point sources for nonpoint source emission through a trade agreement is not found within any nutrient trading statute and leaves the trading policies subject to potential high resolution costs (lawsuits) in the future as policy and guidance are not reflective of statute. Efforts to address the potential liability concerns of point sources should be incorporated into trading policy as well.

Limitations

Limitations of this analysis include the inability to measure outputs commensurate terms due to the monitoring requirement differences. In addition, actual outcome, in nutrients reduced was also not possible due to the differing and multitude of policy differences. A smaller study would be necessary to quantify outcome of policy in addition to direct measures through farmer survey of practices. Other limitations of this analysis are that output is attempted to be explained by policy

design and monitoring requirement. There are myriad other factors that explain output and that may affect outcomes, such as budget and choice of which department is responsible for the program (e.g. if the department id conservation or regulation focused). The monitoring categories direct, ambient self and volunteer were not explored in this research. There is potential for further research to quantify volunteer monitoring compared to other monitoring with the thesis that costs would be substantially lower. Other research beyond this approach would be interviews and surveys to detail capacity and gaps in capacity including: third parties, government officials responsible for monitoring, and farmers to retrieve more refined estimates of monitoring cost and factors that affect participation.

Conclusions

This comparative policy analysis was conducted to examine the transaction cost of monitoring to determine policy effects between and among states' choices for nonpoint source agricultural nutrient pollution. The research questions were to determine if: 1) participation in one policy, which is included as a requirement in a second policy, encourages participation in the second policy; 2) including one policy as a requirement of a second policy reduces the transaction cost of monitoring; 3) one policy increases or decreases cost effectiveness of monitoring than the other policy and 4) if outputs (and eventual outcomes) can be improved based on comparison of multiple states and differing policy design. The policy choices in Maryland, Pennsylvania, and Virginia were compared using a framework suggested in Weiss et al. (2014) and policy outputs and estimated monitoring costs between nutrient management and trading and policy effect were qualitatively and quantitatively analyzed.

Policy outputs demonstrate participation in NMP may increase participation in NTP in an incentive-based policy design as demonstrated by data from Virginia. With a modest amount of credits generated (4,688 N and 1,221 P) Virginia appears to have a current policy setting that is encouraging trade. Maryland has strong participation in NMP (5,350 plans, 98% participation), which is as a result of regulation, and no participation in NTP to date. Transaction cost of monitoring may be lowered by including NMP into NTP (as potentially demonstrated by monitoring policy design in Virginia) but is not necessary to induce participation in NTP, as shown by data from Pennsylvania where the highest amount of credits have been generated (299,859 N certified, 253 P certified). Virginia had the lowest potential monitoring costs overall due to policy design: the *local entity* with *non-regulatory* farmer relationship is responsible for monitoring, a *small set* of BMPs and is able to not only monitor plans, *but the additional practices* that are implemented – which can include nutrient trade. An incentive based framework enables strong relationships with farmers: “Programs that have successfully attracted farmers to participate in trading or incentive programs rely heavily on existing embedded ties with farmers and intensive personal interactions” (Chesapeake Bay STAC, 2013, pg. 4; Breetz et al., 2005; Fisher-Vanden and Olmstead, 2013). Research has also suggested a synergistic relationship between cost-share programs and water quality trading (Breetz and Fisher-Vanden, 2007) where the programs are complementary and the presence of water quality trading may also lower cost share rates (Caplan, 2013). For Virginia, this would be a trifecta of nutrient policy success: incentive based cost-share policy increasing trading participation thereby reducing overall cost-share totals and monitoring costs.

Maryland and Pennsylvania had potentially relatively higher costs than Virginia with NTP even though NMP is included as part of NTP. Maryland has potential obstacles to overcome such as the compatibility of a highly regulatory environment inducing participation in an incentive-based market. Pennsylvania NTP participation may indicate that barriers are lower for participation but obstacles remain due to federal regulators demand for monitoring in the status quo. Pennsylvania may benefit from observing Virginia's design and implement a cost-share, tax incentive, or support trading full-on where NMP are rolled into other incentive based policies as opposed to regulatory policy. However, U.S. EPA regulators have indicated that Pennsylvania has to demonstrate baseline compliance before trade can be used (PADEP Phase II Supplement, 2016). This is an outside regulatory constraint to the market and could be explored in further research.

In all three states, NTP design increased monitoring requirements from NMP, which will have direct implications for monitoring costs. Similarly, other research on transaction costs of nutrient trade indicate that the gains from nutrient trading are diminished by the high transaction cost of the policies (Ruppert, 2004 pg. 34; Fisher-Vanden and Olmstead, 2013). If the nutrient trading policy is supposed to reduce costs for nutrient abatement, then all aspects of potential cost increases (such as monitoring) should be balanced with increased certainty of nutrient reductions (policy outcome). Virginia's policy design has the potential to lower the cost of monitoring in NTP compared to the other states and potentially compared to NMP alone if the benefits in NTP are higher. In addition, Virginia requires trade to happen through third parties and established third parties are evident in Virginia's nonpoint source

nutrient credit registry with twelve companies facilitating trade (Virginia's nonpoint source nutrient credit registry).

Any nutrient policy output (plan or credit) is fraught with complications and lacks positive evidence that nutrient reduction outcomes are improved simply by having a plan or credit "on the books." The only mechanism proposed to improve this uncertainty in nutrient trade are trading ratios which also increase costs of nutrient trade by requiring more than one pound of nutrient be purchased for each pound needed for compliance (Horan, 2000; Horan and Shortle, 2005). In addition, shifting cost of treatment that accounts for uncertainty (using trading ratios) and shifting monitoring responsibilities of the nonpoint source to the point source indicates that costs of the nutrient externality are just shifted from the nonpoint agricultural source to the point source (Ruppert, 2004, pg. 36.) It is argued elsewhere that regulation on point sources alone causes the cost differential that makes trading attractive in the first place, and shifting additional transaction costs in trading may only make the transactions costlier (Ruppert, 2004). That is to say, nonpoint sources are cheaper specifically because they do not have stringent regulation and caps, and monitoring requirements of current trading policies further keep the nonpoint source "cheap" and the increased cost of monitoring, if fully recognized would increase the costs of credits. Virginia requires trades occur through third parties, and all the nonpoint source credits available are through limited liability corporations. Further analysis of the potential for this third party arrangement would be necessary to determine if this arrangement truly lowers monitoring (and resolution). While comparative analysis approach highlights institutional malfunctions (imperfections), including that institutions tend to "fail together" (Komesar, 1994, pg. 6; Cole, 2013) it is important to

choose not only policies that remedy current failures but that explicitly recognize the failures so as to not perpetuate them with new policy.

Chapter 4

SIMULATING SUBSTITUTABLE WATER QUALITY POLICIES: PAYMENTS FOR OUTCOMES VERSUS PAYMENTS FOR PRACTICES

Although a longstanding concern exists regarding policy effectiveness and coherence of overlapping environmental policies (Sharp and Bromley, 1979), these institutional design issues remain understudied. The incentive problem of stacking, in which multiple policies incentivize complementary ecosystem services, has attracted research attention. There is concern that “double dipping” would impact cost effectiveness of the service provision especially if policies are administered in a “piecemeal fashion” (Woodward, 2011). In addition, there is potential for net ecological losses due to current scientific limits to partition services (Robertson, et. al. 2014). Truly cost-effective environmental policies must be coordinated and understood in light of stacking and other policy interaction problems.

This paper addresses a related institutional interaction problem involving (often imperfectly) substitutable policies. For instance, Goulder (2013) found that in the air-quality market, multiple programs with varied regulatory stringency in different jurisdictions collapsed prices in the sulfur dioxide market. That paper exposed the danger that new environmental policies may substantially undercut the effectiveness of an existing policy. Substitute policies may jeopardize the ability of governments to achieve policy goals, but they also can generate confusion among service providers (i.e., ecosystem service providers) with mixed price signals (i.e., incentive payments). Of greater concern, substitute policies can create policy incoherence that will require future policy corrections, especially when policies assign permanent property rights (as do PES and trading programs) rather than regulatory approaches. Recently,

Bromley (2015) detailed the efforts whereby U.S. fisheries policy repeatedly attempts to correct the previous policy's failures.

The impact of water quality policy on the reduction of excess nutrients lags those in other media, such as air and fisheries, because of the nonpoint source problem. Recent advances in water quality modeling which predicts field-level nonpoint loadings has triggered new efforts to promote "performance-based" water quality trading (WQT). Performance-based WQT, whereby a modeled current and future load differential in pounds of nutrients can be traded, currently exists in jurisdictions such as Maryland, U.S.A. Water quality trading, consequently, is a new and growing substitute policy for the related cost-shared best management practice (BMP) policies. The BMP policies are a type of PES that are the principal incentive-based tool for addressing nonpoint source nutrient pollution from agricultural lands. It is important that the research community studies the substitutability of WQT and PES and offers timely advice before governments unknowingly institute policies that render implementation and outcomes ineffective.

Only a small number of papers examine substitutable water quality policies. Caplan used a multi-lateral contract with asymmetric nonpoint source cost information (where the regulator does not know abatement cost) and characterized the second-best abatement level when the regulator sets cost-share rates in the presence of a water quality market (2013). Caplan estimated that cost-share rates could be lower and more flexible with joint policy implementation (2013). Other studies demonstrated that efficiency gains are dependent upon coordination through targeting cost-share programs in the presence of water quality trading programs (Horan et al., 2004). Also suggested is the possibility that transaction costs can be reduced and participation

increased in a water quality trading market by establishing partnerships between federal cost-share programs and the market in various ways such as “brokering,” “screening,” or “recruiting” farmers (Breetz and Fisher-Vanden, 2007, p. 210). With research indicating that agricultural cost-share programs are “over-subscribed” (Breetz and Fisher-Vanden, 2007, p. 202) and reportedly inefficient (Claassen et al., 2008), understanding the aspects of policy interaction between existing incentive programs and newer programs, such as nutrient trading, is imperative to not only develop the programs cost effectively but ultimately incentivize participation by agricultural nonpoint sources.

This paper builds on these studies with a new conceptualization of the substitute-policy problem, but the main contribution comes from collection and analysis of a unique data set. These data allow estimation of two existing water quality policies may interact as WQT expands. It is clear that PES policies are just government procurement programs, but WQT also has aspects of procurement in that the government sets a pollution cap on point sources who must (1) meet the cap; or (2) procure abatement from point or nonpoint sources to exceed the cap. Water quality improvements are procured indirectly under WQT by the government’s cap and also under PES where payment is made for a service that results in water quality improvement. Recognizing the similarity gives rise to researchable questions about procurement efficiency and about the interaction of the programs:

- (1) Does PES incentivize least cost abatement?
- (2) Will a new WQT policy impact participation in PES?
- (3) Will high-productivity abaters leave PES for WQT such that future PES programs will systematically procure less abatement?

This paper informs these questions with a data on cover crops (CCs) in the Delmarva Region of the U.S.A. The results will demonstrate heterogeneity in CC abatement over a variety of treatments, and hence heterogeneity in procurement cost. Then the incentives of planting CCs in PES and WQT will be compared. The comparison requires a novel method to calculate the joint incentives for WQT from N and P markets, including a sensitivity analysis.

Methods

Although PES and WQT policies incentivize the exact same land practices, the procurement of abatement is paid in different ways. In PES programs, governments pay farmers “per acre” for adoption of BMPs, while in WQT point sources pay for modeled environmental outcomes in nitrogen and phosphorous markets (N and P) that arise from the BMP adoption. The fundamental challenge to analyze the joint performance of PES and WQT is that PES incentivizes N and P abatement services with a single incentive price, while WQT offers separate incentives for N and P. This paper does not address the anticipated combination of a third service in WQT, erosion. Furthermore, there is no robust WQT market where the researcher will find prices for N and P abatement. As no prior work could be identified that combined systematically the WQT prices of N and P, this section outlines a new approach to makes WQT and PES incentives comparable, including a systematic sensitivity analysis.

Abatement Productivity Heterogeneity

Under current policy design, a BMP on a farm lowers the load of N and/or P, and the amount abated is the same regardless of whether the owner is paid via WQT or

PES. In the WQT policy, abatement productivity is modeled with per acre variables N_i^k and P_i^k , for farm i and BMP k .

Farms ought to differ in abatement productivity even when one controls for acreage and BMP type because of different local weather, on-farm soil types, on-farm slopes, etc. (Wieland et al., 2010; Wieland et al., 2009). This study uses load delivered to the Chesapeake Bay because this is the load that would be available in the WQT market. The null hypotheses tested with the data described below are that there is no difference in abatement productivity across the sampled fields, i , and across the sampled BMP treatments, k :

H0

(Within treatment homogeneity)

$$N_{i1} = N_{j1}, \forall i \neq j; P_{i1} = P_{j1}, \forall i \neq j.$$

H0

(Between treatment homogeneity)

$$N_i^k = N_{il}, \forall k \neq l; P_i^k = P_{il}, \forall k \neq l.$$

H0

(Global homogeneity)

$$N_i^k = N_{il}, \forall i \neq j, \forall k \neq l; P_i^k = P_{il}, \forall i \neq j, \forall k \neq l.$$

Within, between, and global heterogeneity is anticipated.

The insights in this paper will flow from this anticipated heterogeneity. The greater the heterogeneity, then the steeper the slope in the farmers' abatement supply curve—even with homogeneous adoption costs. In other words, some farmers would be able to supply abatement at lower costs than others. Furthermore, this heterogeneity directly drives this paper's main result about systematic selection in PES because (A) PES programs do not distinguish abatement productivity; and (B) the

introduction of the substitutable WQT allows those with high abatement productivity to select into WQT, potentially leaving the PES program with the least productive farms.

An Economic Model of Substitutable Water Quality Policies

Incentives from WQT are the price of nutrients abated on the market ($PRICE_N^{WQT}$ and $PRICE_P^{WQT}$), while the incentives in PES are the payments for the type of BMP per acre ($PRICE_k^{PES}$). Perfect procurement substitutability occurs when the incentive payments produce an equality for any given BMP, k , on any given farm, i :

$$PRICE_N^{WQT} N_i^k + PRICE_P^{WQT} P_i^k = PRICE_k^{PES}$$

This substitutability condition is unlikely to be satisfied for most farms because of heterogeneity, and this, in turn, is important for systematic (or cost effective) selection because some farmers will earn more in one program than another. When farmers recognize the earnings differential, they will select into the higher paid program. Condition (1) contains three exogenous price variables, which arise from three different processes. The WQT prices come from the market equilibria that are driven by supply (heterogeneous farmer adoption costs) and demand (heterogeneous point source abatement costs). PES prices come from internal agency decision-making and budget constraints. Because there is no functional relationship between on-farm abatement productivity and these exogenous prices, there is almost no chance that the perfect substitutability condition will be satisfied for any given farm. Thus, individual farms will not be indifferent between WQT and PES. Profit-maximizing farmers will be drawn to one program or the other. All else equal, the low-abatement-

productivity farms will select into PES because $PRICE_k^{PES}$ is not affected by productivity. One similarly expects the more abatement-productive farms to enroll in WQT.¹⁹

The original, behavioral-economics insight driving this analysis is as follows: Farmers will participate in the program that offers the largest payment and, because the PES program currently exists and its payments are not affected by abatement productivity, PES creates a price floor in the newer WQT market. Condition (2) shows this price floor:

$$PRICE_N^{WQT} N_i^k + PRICE_P^{WQT} P_i^k \geq PRICE_k^{PES}$$

This condition means that for any given BMP, k , the combination of WQT incentives must generate a combined payment at least as large as the PES payment. PES forms the lower bound because: (A) it was the initial program and existing PES participants will not switch to WQT unless they can get more; and (B) PES offers one price to participants regardless of abatement productivity.

Another behavioral condition is that farmers must receive net benefits from adoption of any BMP—really, the condition is that they must adopt the BMP with the highest (positive) net benefits. Benefits include the incentive payment from WQT or PES plus any on-farm benefits from adoption, which include improved soil health,

¹⁹ If this tendency of certain farms to be drawn to one program is driven by an important environmental or behavioral condition, then the existence of imperfectly substitutable programs results in systematic selection. If the selection process is unobservable by the regulator, then this adverse selection process will undermine policy effectiveness.

wildlife viewing opportunities, and hunting. Nonpecuniary benefits might also exist, such as greater satisfaction with one's environmental stewardship. The sum of those benefits must exceed the BMP's adoption costs, which will be driven by farmer-specific and land-specific processes. This paper abstracts from this adoption condition, modeling the full procurement supply curve in a specific region from the perspective of a perfect-price-discriminating abatement demander.

Procurement Cost Heterogeneity and A Nutrient Index

As no robust WQT market prices exist and as they are impossible to simulate with unobservable real-world point and nonpoint source abatement cost data, this paper develops an index to test for a range of possible market outcomes. This index account for the minimum “procurement” costs is from the perspective of the government, or the cost if the government could offer the minimum compensation per pound of abated aggregate N and P nutrients. The first step in developing this index follows Hanson and McConnell (2008; see equation 2 on p. 215), who modeled heterogeneous procurement cost by estimating government payments per pound of nutrient abated: $c_i^{N,k} = PRICE_k^{PES}/N_i^k$ and $c_i^{P,k} = PRICE_k^{PES}/P_i^k$. Each farm i can supply a varying number of acres, a_i , at these costs. Following the price-floor argument in equation (2), the PES price is used in this calculation. The cost of government offering the minimum compensation per pound of abated aggregate N and P nutrients measure differs slightly from the standard supply curve, which in this example would be the opportunity costs to the farmers. Instead, the government goes to the WQT market to buy nutrient abatement. Although Hanson and McConnell focus only on N abatement, BMPs often produce N and P abatement, as well as other services, such as reduced sediment (2008). For example, USDA NRCS Practice Code

340 lists at least seven services beneficial to the farm and environment. Thus, this section builds a model to aggregate the two WQT incentives into a single payment.

Assume a variable, $\pi = PRICE_N^{WQT} / (PRICE_N^{WQT} + PRICE_P^{WQT})$, that captures the relative credit price of N to P in the WQT market. Although these prices are unknown, π and the price-floor insight, allows us to write a condition for a farm's incentives in the WQT market for delivering an aggregated nutrient with an imputed index procurement cost (*IIPC*):

$$IIPC_i^{\pi,k} = \pi c_i^{N,k} + (1-\pi) c_i^{P,k} = \pi PRICE_k^{PES} / N_i^k + (1-\pi) PRICE_k^{PES} / P_i^k$$

This study will use three sensitivity measures of relative WQT market prices: N credits are approximately three times the price of P credits ($\pi=0.75$), credits cost the same ($\pi=0.5$), and N credits are approximately one-third the price of P credits ($\pi=0.25$).

An original WQT supply curve algorithm estimates the range of market outcomes for any BMP, k , using Chesapeake Bay Nutrient Trading Tool (CBNTT):

1. Draw a random sample of actual farm fields, including their acreages, a_i ;
2. Use CBNTT to model abatement from a BMP, k : N_i^k and P_i^k , measured in lbs.;
3. Calculate $c_i^{N,k}$ and $c_i^{P,k}$, measured in \$/lb.;
4. Calculate $IIPC_i^{\pi,k}$, measured in aggregated nutrient \$/lb.;
5. Populate a simulation of fields from an empirically based population where PES is implemented;
6. Order the population (cost effectively) from greatest aggregated nutrient to least \$/lb.;

7. Create a graphical supply curve for a given $(\pi=0.5, k)$ pair by ordering the entire population (all $a_i IIPC_i^{\pi,k}$) from smallest to largest where the horizontal axis is acres and the vertical axis is \$/lb.; and,
8. Bound likely supply curves by repeating step 5 for $\pi=0.25$ and $\pi=0.75$.

This aggregated nutrient supply curve ranges from the most- to least-productive aggregate abatement. It is anticipated that heterogeneity arises from the within and between-treatment productivity and the supply curve is the most useful way to display the likely procurement cost. In addition, this approach conveys the unknown WQT prices with a sensitivity analysis.

Data

This paper uses a randomly generated sample of farms and typical agronomic data and processes these data through a working WQT platform, CBNTT. Actual program incentives and CC adoption in acres from an existing CC PES program are also used.

Random Selection of Farm Fields with Quantum Geographic Information Systems

The sample of cornfields in the Chesapeake Bay drainage was generated from the USDA NASS CropScape crop data layer (USDA CDL, 2012). Watersheds, roads, parcel boundaries, hydrology, and zip code shape fields were obtained from State of Delaware and Kent and Sussex Counties (State of Delaware, FirstMap) and imported into an original Quantum Geographic Information System (QGIS, 2009) project.

CropScape does not provide data by watershed and the USDA CDL was clipped in QGIS using watershed layers obtained from the State of Delaware. Spatial analysis tools in QGIS were used to stratify the crop layers then generate random

points within the corn layer. This procedure provided an unbiased way to obtain a sample of the population of cornfields in Kent and Sussex County, Delaware (Figure 2). The agriculture crop layers were first separated to polygons for the crop of interest, in this

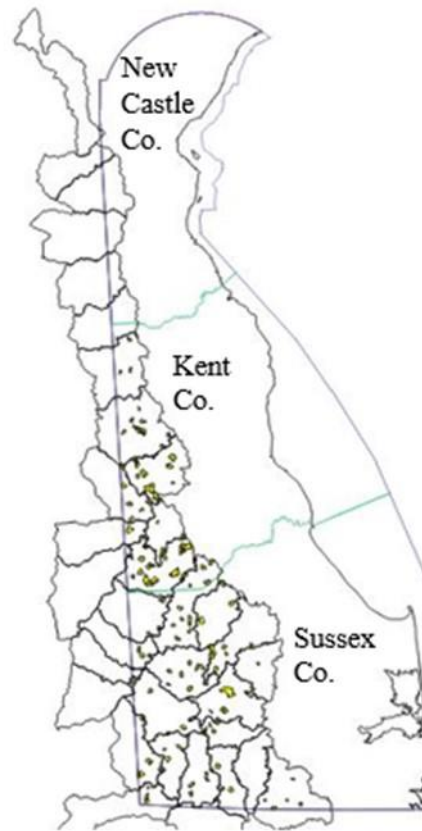


Figure 2 Random sample of cornfields in Kent and Sussex Co., Delaware (Chesapeake Bay drainage) generated from the USDA NASS CropScape crop data layer (USDA CDL, 2012) using Quantum Geographic Information System (QGIS).

case, corn. Using the corn polygons as the sample frame allowed every unit in the population to be unambiguously identified with every unit having equal chance of selection. An original spatial random-sample method selects point locations by choosing x-coordinates and y-coordinates (units) at random (Figure 3). This is convenient when sampling agriculture because using individual parcels or farm fields generates a selection bias of larger parcels or fields. Because each unit in the QGIS spatial sample is equal (i.e., x, y coordinate), each with the same probability of selection, potential for size bias is greatly reduced.

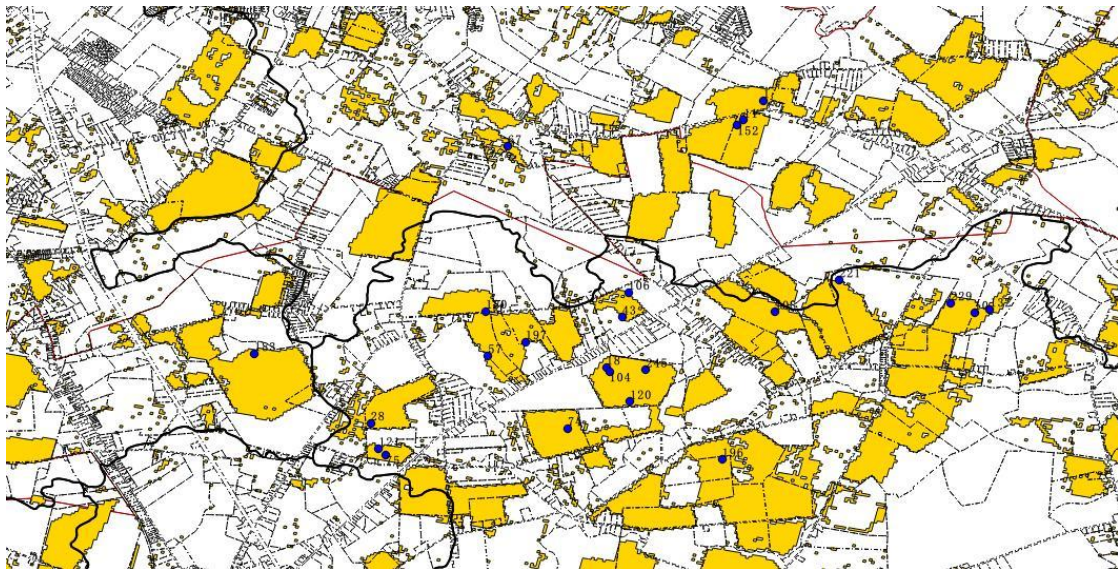


Figure 3 Example of QGIS data set: data points (circles with numerical ID), corn fields (shaded polygons), roads and road names, Hydrologic Unit Code 12 watershed boundaries (black outline).

The data for the sampled cornfield parcels were input into a spreadsheet program after duplicate points in the same polygon were eliminated. A total of 270

viable points in individual fields were recorded (96 Kent and 174 Sussex County). Of those fields, the first 144 fields were used to apply agronomic variables and BMP treatments. The number of fields was chosen to be divisible by agronomic variables. The 144 fields and their encompassing tax parcel polygons were drawn into CBNTT in the aerial photograph interface. Data recorded in an excel spreadsheet included latitude and longitude, irrigation (central pivot visible), watershed code HUC-8, HUC-10, HUC-12, visible watercourses, and field acreage as delineated in CBNTT. The sample of fields included 9,192.5 acres in Kent and Sussex County Delaware.

Cover Crops, Agronomic Data, and Treatments

In Maryland, both PES and WQT policies exist for CC. Cover Crops are regarded as one of the most cost-effective, incentive-based abatement practices and thus have drawn substantial attention from policy makers. In addition, CC can be applied in many different treatments (timing, seed, etc.), which produce different amounts of N and P abatement. Observed adoption patterns reflect this heterogeneity and thus provide some guidance on how farmers choose among competing PES options. Maryland's payment structure is designed to pay the highest prices to the practices that reduce the most nutrients (e.g., early planting, rye seed are paid more). Farmers cite flexibility as a reason for choosing to plant cover crops. Maryland's program is very flexible with several payment levels, therefore, Maryland's payment per acre associated with the selected treatment categories were applied to the sample of corn fields in Delaware. Compared to Maryland, Delaware does not have a robust cover crop program; therefore, the selected fields reflect a potential sample that has been affected to a lesser extent by cover crop nutrient reduction policies.

Agronomic data for the sample of fields were obtained from published data and information acquired through interviews with Delaware Agriculture Extension agents. Individual field data was not available for the Delaware fields. The agronomic data entered into CBNTT (Table 4) is characteristic of field conditions in the Coastal Plain of Delaware.

Table 4 Chesapeake Bay Nutrient Trading Tool (CBNTT) Field Attributes, Input Constants and Variables, Cover Crop Treatment Levels, Output from Nutrient Net

<i>Field Attributes</i>	<i>Values</i>	<i>Type of Variable</i>
<i>Land Characteristics</i>		
Acres	Range 2.66 ac – 362.24 ac	Varies by field
Delivery Ratio	N (0.55-1.0), P (0.69-1.0)	Varies by field
County	72 Kent, 72 Sussex	Varies by field
Irrigation (if center pivot visible on aerial photograph)	75% efficiency	Observed variable input
Current load	N (lbs./ac.) P (lbs./ac.)	Varies by field
<i>Agronomic inputs</i>		
Crop type ¹	Corn Grain	Constant input
Corn planting date ¹	May 5	Constant input
Planting method	30-inch row crop planter	Constant input

Table 4 cont.

Soil P Concentration 5-year average (2011-2015) ²	Kent County 57 – 158 (ppm) Sussex County 101 - 275 (ppm)	Simulated uniform variable input
Type of Manure	Solid/Poultry Broiler	Constant input
P Concentration ³	23 lb./Ton (Total P)	Constant input
N Concentration ³	60 lb./Ton (60% PAN)	Constant input
Application rate	2 Tons/Acre	Constant input
Application date	April 1	Constant input
Moisture content ³	28.65%	Constant input
Phytase treatment	Yes	Constant input
Poultry litter treatment	Yes	Constant input
<i>Inorganic fertilization</i>		
First application ⁴	35 lb./Acre	Constant input
Date/incorporation	May 5, 4 inches	
Second application ⁴	Range 23 – 69 lbs./ac.	Variable based on yield
Date	June 1, no incorporation	
<i>Cover Crop treatments</i>		
<i>(2 x 3 x 2)</i>		
<i>Tillage (2 levels)</i>		Constant input
No-Till	>30% residue	
Conventional, chisel till (April 15) ¹	Manure incorporated 4 inches (within 48 hours) April 3, <30% residue	
<i>Corn Harvest / Cover Crop Planting Date (3 Levels)</i> ⁵	Constant input	

Table 4 cont.

Early	Sept. 15/Sept. 30	
Standard	Sept. 30/Oct. 15	
Late	Oct. 15/Oct. 30	
<i>Cover Crop Seed Type (2 Levels)</i> ⁶	Rye Wheat	Constant input
Dependent Variables		Output

Notes:

1) Corn for grain encompasses a high percentage (160,000 acres in 2012 National Agricultural Statistical Service) of planted acreage in Delaware each planting season. Corn necessitates fertilizer use, unlike soybean, which does not require nitrogen fertilizer. Chisel till between manure application and corn planting date.

(http://www.nass.usda.gov/Statistics_by_State/Delaware/Publications/Annual_Statistical_Bulletin/2009/Page30.pdf, Philip Sylvester, DE Extension Agent, personal communication).

2) Five-year average for soil phosphorous concentration (ppm) were randomly assigned to the fields within a range of values based on previous data collection (Karen Gartley, unpublished data, University of Delaware, Soil Testing Program).

3) Manure phosphorous and nitrogen content based on Chesapeake Bay model. CBP expert panel report

(http://www.chesapeakebay.net/documents/Recommendations_to_Estimate_Poultry_Nutrients_Phase6_04172015.pdf).

4) Inorganic fertilization (Philip Sylvester, DE Extension Agent, personal communication.)

5) Cover crop planting dates based on range for payment

(http://mda.maryland.gov/resource_conservation/counties/2015CoverCropProgram.pdf.)

6) Wheat and rye seed were selected based on payment schedule -rye is paid more based on studies demonstrating higher nitrogen removal rates

(http://mda.maryland.gov/resource_conservation/counties/2015CoverCropProgram.pdf)

The land characteristics and agronomic data were combined in CBNTT to establish a single “current” modeled N and P load (lbs./ac). Current field input for soil phosphorous concentrations were the reported average of the last five years (2011-2015), 25th to 75th percentiles for Kent and Sussex County for samples analyzed by the UD Soil Testing Program. Each field received a randomly assigned, non-repeating

value from the continuous range: Kent (57 – 158 (ppm)) and Sussex (101 - 275 (ppm)) counties.

Nutrient applications followed the general agronomic practices in Kent and Sussex Counties and were based on interviews with Agriculture Extension agents in Delaware. Manure N and P concentrations and moisture content were obtained from the Chesapeake Bay expert panel report. Manure applications of 2 tons/ac were assumed for all fields to align with manure availability and P-based manure rates common throughout the region. Two applications of commercial N fertilizers were applied as a supplement to manure N to achieve the University of Delaware N fertilizer recommendations for grain corn based on yield goal (1 lb. N per bushel expected yield, University of Delaware, Soil Testing Program). The initial application of commercial N was applied at corn planting (May 5) at a fixed N rate of 35 lb./ac, which was applied 2 in. below and 2 in. to the side of the seed (2 × 2). The second variable N application was based on the CBNTT yield value and was applied to the soil surface (dribble) on June 1 to simulate sidedress N application when the corn is roughly 12 in. tall (V5-V6). The following formulas were used to determine the N rate for the second inorganic N fertilizer rate:

$$\begin{aligned} \text{Inorganic 2 N rate (lb./ac)} &= \text{Total N application rate (based} \\ &\text{on 1 lb. N per acre as dictated by CBNTT yield value)} - \\ &\text{Manure N rate (Plant available N (PAN) at 60\% of total} \\ &\text{manure N (72 lb./ac PAN))} - \text{inorganic 1 N rate (35 lb./ac} \\ &\text{N)} \end{aligned}$$

Manure (60% plant available nitrogen (PAN)) + *inorganic 1*
+ *inorganic 2* (based on CBNTT yield value) [2 Tons/ac (60
lb./Ton (60% plant available nitrogen (PAN))]+ 35 lb./ac +
variable second application (lb./ac) = yield calculated from
CBNTT

This formula reflects fertilization based on crop removal rates and is reflective of what would be required in a Nutrient Management Plan (Sims and Gartley, 1996).²⁰ The second variable application of inorganic N ranged from 23 – 69 lbs./ac. applied June 1 with no incorporation.

The treatments followed a 2 x 3 x 2 full-factorial design ($k=12$). The 12 CC treatments were added as to CBNTT as “future” crop management to calculate new modeled loads. The output of N and P is the difference (reduction) in N_i^k (lbs./ac.) and P_i^k (lbs./ac.) from current load with the treatment applied as a future practice. The CC treatment combinations were based on actual options offered by Maryland for tillage (2), planting date (3), and seed choice (2). The sample of fields ($i=144$) received no-till ($i^{NT}=144$) and conventional (chisel plow) till ($i^{CT}=144$) both planted with 30-inch row crop planter. Each tillage received the $k=6$ treatments of seed and planting date combination. The CC planting dates were set to reflect the typical corn harvest dates in Delaware and generally reflect the enrollment data described below. In sum, there

²⁰ Expected yields in the CBNTT are not reflective of Delaware expected yield for irrigated acres. Delaware Code, Title 3 Chapter 20 Nutrient Management Planning section requires expected yield calculation be the average best four years from the last seven years. NASS reported data for Kent and Sussex County indicates the irrigated corn yields over 200 bu/acre. The CBNTT yield calculations were lower than 200 for irrigated fields. Therefore, the CBNTT yields were used in the formula to avoid over application of nitrogen.

were 1,728 different field-level observations on N_i^k and on P_i^k individually. There were 144 observations on acreage, a_i . The N_i^k and on P_i^k load reduction recorded was the reduction to the Bay (lbs./ac.), which included the CBNTT assigned delivery ratio (equal to 1.0 or below). This ratio reflects nutrient transport process from the edge of segment to the Bay. For example, the closer a field is to the Bay the more likely the delivery ratio assigned by CBNTT is 1.0 due to the nutrients applied having direct transport to the Bay. Fields farther from the Bay would have lower delivery ratios indicating nutrients are absorbed or cycled in natural processes and portions of the nutrient applied to the fields do not reach the Bay.

Policy Setting

The CBNTT platform was chosen to estimate nutrient reductions because it is a leading performance-based trading model²¹, it is used in Maryland's WQT market, and it was built out to cover the adjacent State of Delaware's land within the Chesapeake Bay Watershed. Farms in Delaware were targeted because the state has no trading program and, furthermore, has far fewer PES (and CC) policies relative to Maryland. This allowed the researchers to study a landscape that has yet to adjust fully to robust PES program or a nascent WQT—an adjustment process that may alter agronomic and land-market choices and bias the random sample of fields.

However, Kent County, Delaware, is adjacent to Queen Anne's County, Maryland, where the PES behavioral data are collected. There is no natural

²¹ As a note there are other platforms states use to calculate nutrient reductions and credits (See for example Bayfast at <http://www.bayfast.org/default.aspx?AcceptsCookies=yes>).

demarcation between these counties and all three counties studied are on the Atlantic Coastal Plain. Maryland's PES for CC has developed a dedicated state revenue source, with \$22 million (2015-2016) earmarked to fund over 400,000 acres of CC annually to meet the acreage enrollment goals in their watershed implementation plan (State of Maryland Bay Restoration Fund Annual Report, 2015; State of Maryland Department of Agriculture Cover Crop Program, 2015-2016). Maryland's program has a matrix of flexibility options (i.e., treatments) for farmers to choose from with corresponding per-acre payments for non-harvested cover crops that range from \$45-\$100/acre (Maryland Department of Agricultural Cover Crop Program, 2014). Flexible payments are designed to target CC characteristics that positively impact water quality, such as higher payments for specific watersheds, early planting, using cover crops in fields where manure was spread, and planting rye (Maryland Department of Agricultural Cover Crop Program, 2014).

Cover Crop Enrollment Data

Queen Anne's County provided records of acres paid in 2014-2015 by several CC treatments (table 5). Cover crop adoption was estimated at 45,759 acres at the current payment levels. Queen Anne's County has 117,900 acres of corn and soybean fields (USDA NASS Census, 2012), which are the main crop fields that are planted in winter CC. Thus, the researchers assumed that about 39% of farms will enroll in an aggressive PES program for CC.

Table 5 Acres in Cover Crop Treatment Queen Anne's County, Maryland 2014-2015 and payment per acre

Seed	No-till			Other-Till		
	Early	Standard	Late	Early	Standard	Late
	9/30	10/15	10/30	9/30	10/15	10/30
Rye						
Acres planted (est. per acre payment)	0 (\$90)	377.8 (\$80)	530.4 (\$70)	203.8 (\$80)	559.3 (\$75)	1283.9 (\$70)
Wheat						
Acres planted (est. per acre payment)	0 (\$80)	3690.0 (\$70)	7212.1 (\$60)	0 (\$70)	17175.7 (\$65)	14726.1 (\$60)

*Data on cover crop acreage received from the Queen Anne's Soil Conservation District Manager (June 2 and June 5, 2015) via e-mail communication. CC planting dates selected for data herein. Payments per acre correspond to Maryland Cover Crop program, however counties may distribute payments slightly different.

The sample of fields (9,193) acres were expanded to a simulated population of acreage in Queen Anne's county (45,759 acres out of 117,900 acres of total corn and

soybean). The sample of fields was selected cost effectively (i.e., cheapest acres selected first) to generate a simulated supply curve (steps 5 and 6 in the methods section). The selection method employed cumulative acreage based on the proportion of acres recorded, as paid in the categories reported by Queen Anne's county up to 45,759 acres (acres of wheat and rye total). There are very few rye acres paid (total rye 2,955.2 acres, Table 5). The proportion of acres in the simulation reflects the proportion in Queen Anne's county (e.g. rye 2,955.2/45,759). The majority of CC were planted in wheat and during the later planting date categories. The results and figures are given below.

Results and Discussion

Figures 4 and 5 show that there is within-treatment, between-treatment, and global heterogeneity in abatement productivity for both N and P. The treatments are in order from left to right (horizontal axis) from highest per acre payment to lowest. The box and whisker plots show heterogeneity in the medians, minima, maxima, 25th percentile, and 75th percentiles across all treatments in pounds per acre. Examples of between-treatment heterogeneity for N: early-planted rye on conservation-till fields ($k=EP, R, CT$) abated a median of 0.7 N lbs./ac., while the modeled abatement on the same planting with no-till ($k=EP, R, NT$) had a median of three times more (2.2 N lbs./ac). Moreover, the two treatments maxima/median differ as well demonstrating within-treatment heterogeneity; the maximum conservation-till abates seven times more than the median value, while the maximum no-till field abates three times less than the median. An even larger between-treatment difference (nine times) is modeled between early-planted rye on no-till (2.2 N lbs./ac.), and late-planted wheat on conservation-till ($k=LP, W, CT$) which abated a median of 0.2 N lbs./ac.

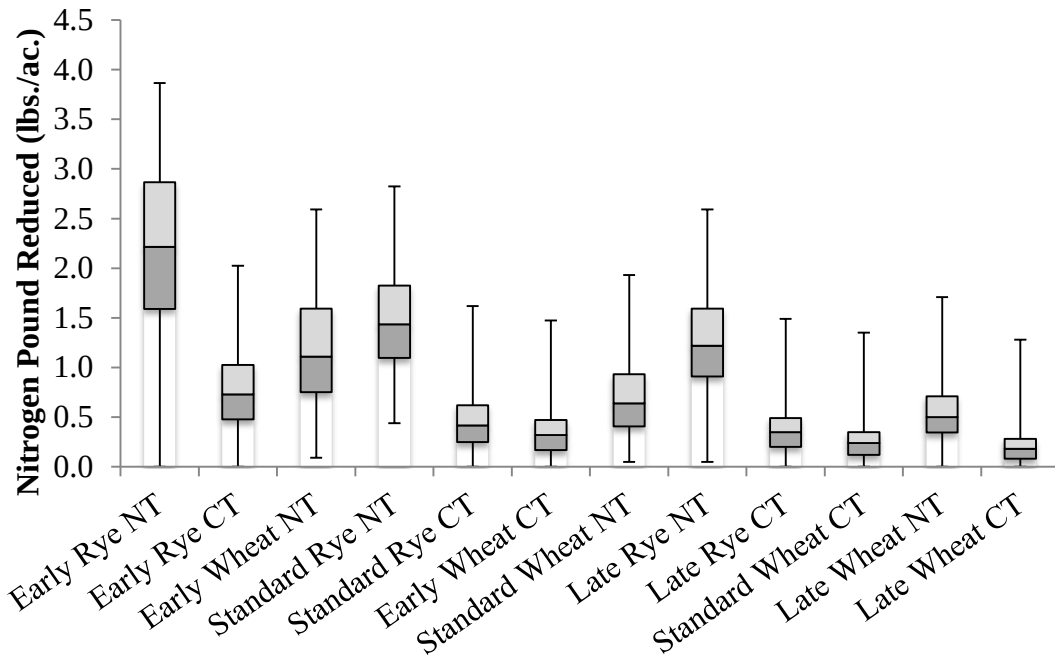


Figure 4 Modeled nitrogen load reduction in pounds per acre for simulated cover crop treatments on 144 fields in Kent and Sussex counties, Delaware with various planting times, tillage, and species variation. Heterogeneity in field reduction is apparent within - and among - treatments. (NT = No-till, CT = Conservation Till. See Table 4 for planting dates.)

Modeled P reductions (Figure 5) demonstrate greater within- and between-treatment variability than N. The treatments are ordered from left to right (on the horizontal axis) from highest per acre payment to lowest. In terms of the median modeled abatement for tillage, the no-till treatments produced more lbs. of N and this pattern is the same for P. The median modeled P load reduction for early-planted rye on no-till fields ($k=EP, R, NT$) is 0.5 P lbs./ac.; the median for the same planting on

conservation-till ($k=EP, R, CT$) is 0.08 P lbs./ac., or about six times lower. The greatest difference in modeled median, between-treatment P load reduction (22 times), was modeled between the early-planted rye on no-till ($k=EP, R, NT$) and late-planted wheat on conventional-till ($k=LP, W, CT$) treatments. Within-treatment variability for P is substantial, with maxima generally three to seven times the median.

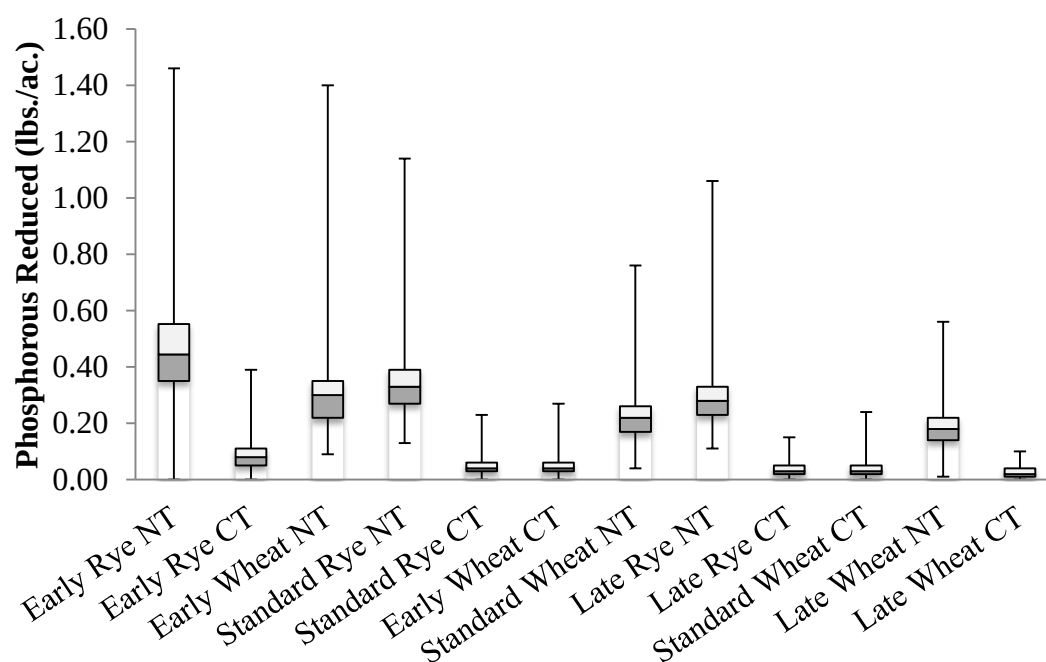


Figure 5 Modeled phosphorous load reduction (lbs.) per acre for cover crop treatments on 144 fields in Kent and Sussex counties, Delaware with various planting times, tillage, and species variation. Heterogeneity in field reduction is apparent within - and among - treatments. (NT = No-till, CT = Conservation till. See Table 4 for planting dates.)

Although the heterogeneity appears obvious in the figures, a controlled statistical test examines whether the sample size is sufficient to demonstrate statistical

differences. Several regressions explained N and P load (lbs./ac.) reduction using the three planting treatments, the two tillage treatments, and several other control variables (acreage, delivery ratio, irrigation, and current load). Table 6 presents the results of the ordinary least square and panel regression with the field set to random effect shows the (controlled) average reductions in terms of the treatment categories (two planting, one tillage, and one seed type versus a base case). Random effects regression was chosen, in addition to OLS, to account for the heterogeneity among the fields that remains constant through the treatments. Importantly, the regression results are denominated in lbs./ac. of N and P abated, and the point estimates can be compared. Although this paper only reports sign and significance, but does not report a test on whether point estimates are all statistically different. The results suggest, all else equal, that no-till abates more N and P than conservation tillage; early planting abates more N and P than standard or late planting; rye seed abates more N and P than wheat; and, irrigated fields reduced more N and P than non-irrigated fields. The soil P independent variable was the only parameter with different signage in the random effects results from the OLS; but over-all the results show that average change in P reduction does not change as soil test P changes. This is a result that indicates the CBNTT accounts for all the factors (not just soil P) that influence P loss. The last independent variable indicates that fields in Sussex abated less N and P per acre than the fields in Kent.

Table 6 Regression Model Results

Parameter Estimates				
Variable	Random Effects Estimate	P OLS Estimate	Random Effects Estimate	N OLS Estimate
Intercept	0.057*** (0.019)	0.119*** (0.010)	1.069*** (0.062)	0.792*** (0.043)
Current (N or P) Load	0.159*** (0.008)	0.117*** (0.005)	0.022*** (0.006)	0.060*** (0.004)
Tillage ¹	-0.094*** (0.009)	-0.139*** (0.007)	-0.928*** (0.028)	-1.056*** (0.027)
Standard ²	-0.061*** (0.005)	-0.062*** (0.006)	-0.416*** (0.025)	-0.400*** (0.028)
Late ²	-0.085*** (0.005)	-0.089*** (0.006)	-0.554*** (0.025)	-0.523*** (0.028)
Seed Type ³	0.083*** (0.004)	0.084*** (0.005)	0.583*** (0.02)	0.583*** (0.023)
Irrigation ⁴	-0.076*** (0.011)	-0.069*** (0.005)	-0.253*** (0.060)	-0.304*** (0.026)
Soil P	-0.0001 (0.0001)	0.0000 (0.0001)		
Sussex	0.074*** (0.015)	0.054*** (0.007)	0.326*** (0.059)	0.407*** (0.026)
R-squared	0.7718	0.7326	0.6578	0.6228

N=144; ***indicates 0.01 level of significance; ** indicates 0.05 level of significance.

Notes:

Base cases:

- 1) Tillage, no-till
- 2) Early planting
- 3) Wheat seed
- 4) No irrigation
- 5) Kent County

Modeled Abatement Productivity vs. PES Payments

These modeled differences in abatement productivity generally match the trend in payments in the current Maryland program. Considering the first research question, if the modeled abatement is correct, then the Maryland's payment system may be cost-effective. Maryland's CC program has higher incentive payments for early planting dates ($k=EP$) and rye seed ($k=R$), and the regression results suggest the pattern of incentive payments may match the incentive payments in a general sense. However, there are very small differences in abatement per acre for the various treatments. This may suggest that increasing payments per acre, even incrementally, may reduce cost-effectiveness. The wide range of modeled abatement observed for EP, R, NT and other no-till treatment suggests that there are acres that produce very little abatement, yet receive the same payment as acres that reduce greater amounts. The payments are unable to capture the heterogeneity of abatement that each field produces, and the fact that each field produces different levels of N and P. The differences may seem small and the section below offers how small differences become significant when abatement is low and payments are high.

A Supply Curve for the Nutrient Abatement Index

The contribution of this chapter to research on substitution of nutrient policy is to offer a combined index of N and P. Currently, there is no optimal way to trade off N and P, nevertheless they are procured together in the PES. Theoretically, this failure means that the problems with matching payments for one nutrient could potentially be compensated by adjustments in the other nutrient. Figure 6 offers a supply curve with sensitivity analysis on the index of CC payments per acre, ordered by procurement efficiency and aggregated nutrient index, $IIPC_i^{\pi,k}$, at three levels $\pi=0.25$, $\pi=0.5$, and

$\pi=0.75$. This supply curve aggregates the outcomes for all observed treatments used in the sample county (no observed plantings of $k=EP, W, NT$; EP, R, NT ; EP, W, CT) into a single curve. The data from Queen Anne's County only includes 204 acres of early-planted rye. Model results suggest that early planting resulted in some of the highest nutrient load reductions. This means that what is missing from the supply curve is the lowest cost acres available, for both N and P reduction (Figures 4 and 5; $k=E, R, NT$). This is important for the analysis of supply based on the current incentive payment because the current PES censors the lowest-cost abatement. This lowest-cost abatement will be easily revealed in the WQT platform, and this may trigger more adoption of early cover crops (recognizing there need to be total benefits to the farm).

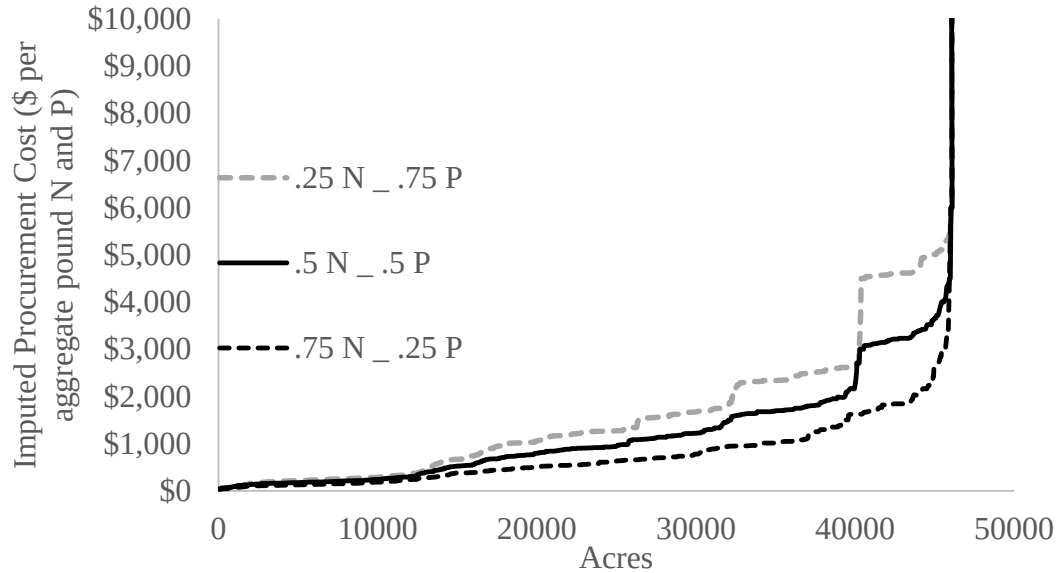


Figure 6 Imputed index procurement cost of modeled nitrogen and phosphorous load reduction based on reported payments made for cover crops (per acre) in Queen Anne's county, Maryland 2014-2015.

Figure 6 shows the minimum cost (under three sensitivity assumptions) to procure nutrients in the WQT market. As argued in the methodological section, this prediction is unavailable from other sources because robust trading does not yet exist in Maryland. This prediction was available because of the insight from recognizing that the WQT is a substitute policy for PES. The procurement cost in cover crop PES creates a minimum price in the WQT market.

To interpret the supply curve, one sees that up to (approximately) 1,800 acres, abatement services will be supplied at a relatively low cost regardless of the assumption (under about \$100 per aggregated nutrient). However, after 1,800 acres, the costs rise quickly of supplying the next 43,000 acres and these costs depend on the assumptions of relative prices. The lowest cost curve makes the least realistic assumption; it is more likely that abatement of P will cost more than abatement of N. Thus, the results suggest that above 1,800 acres, the costs will be high, rising above \$1,000 for aggregated nutrients. These imputed costs are high simply because the cover crop related load reductions (on a per acre basis) are small overall compared to the per acre payment. For example, the most planted treatment in Queen Anne's county was standard planted wheat on conservation till ($k=S, R, CT$); the median modeled load reduction for nitrogen for this practice is 0.24 lbs./ac. This equates to imputed payments for nitrogen of \$67 (at $\pi = 0.25$) to \$203.00 (at $\pi = 0.75$). The median reduction for phosphorous is .03 with imputed payment for phosphorous between \$541 (at $\pi = 0.25$) and \$2,166 (at $\pi = 0.75$). The imputed cost per acre for S, R, CT is between \$744 (.75 N + .25 P) and \$2,233 (.25 N + .75 P) per aggregate N + P pound.

Conclusions

Understanding the aspects of policy interaction between incentive programs, such as nutrient trading and PES, is imperative to develop the programs cost effectively and incentivize participation by agricultural nonpoint sources. The objectives of this study were to: 1) test for nutrient reduction heterogeneity within and among twelve cover crop treatments, 2) determine if PES for cover crops incentivizes least cost abatement, 3) determine WQT impact on participation in PES; 4) if WQT will take high productivity abaters from PES such that PES is less effective.

Methods to test heterogeneity included statistical comparison of nitrogen and phosphorous reductions from a random sample of farm fields. The reductions were output from a nutrient model (CBNTT) that is the platform developed for Maryland WQT. To predict how WQT has the potential to impact PES and how PES will impact WQT a supply curve was generated. To simulate a WQT supply curve, existing PES data and modeled nutrient abatement in N and P were used to generate an imputed index that corrects for the failure of PES to optimally trade off the heterogeneity in N and P reductions. The supply curve modeled the potential WQT supply curve of procurement cost based on the recognition of substitutable policies, farmer profit maximization, and that the existing PES policy has the capability of influencing prices in a policy with similar goals (nutrient abatement). This supply curve addressed questions three and four.

Results showed that there is substantial within-treatment, between-treatment, and global heterogeneity in abatement productivity for both N and P. Controlled statistical tests demonstrated differences existed between treatments. These differences in abatement productivity very generally match the differences in payments in the current Maryland program. However, the per acre payment

heterogeneity can be significant as demonstrated by the supply curve. Some acres produce very little abatement, yet are paid the same as the acres that produce more abatement.

The WQT supply curve generated combined N and P purchased together as PES program does and included sensitivity analysis at three levels, $\pi = 0.25$, $\pi = 0.5$, and $\pi = 0.75$, which produced additional curves. These curves provide insight where payment for one nutrient is compensated by adjustments in payments for the other nutrient in supply of PES and WQT. The supply curve demonstrated the potential price floor created by the existing PES program where costs of procurement can be over \$1,000 for aggregated nutrients. This existing procurement cost in the PES program has the potential to negatively affect low cost abatement supply in the WQT market by providing farmers a higher paying option. This higher paying option would increase the credit prices, reduce gains from trade and affect market operation. Others have estimated credit prices to be very low and below point source costs (Fen Fang, et al., 2005; Stephenson, et al., 2010). The results indicate that the PES policy will affect WQT and at prices above 1,000 acres there may not be gains from trade, i.e., the WQT market will cease to operate (i.e. farmers will stay in PES which pays more).

Finally, Queen Anne's County currently has approximately 117,900 acres of corn and soybean cropland (USDA NASS). Based on the high payments from PES and aggressive program marketing, it seems that only 40-50% of farmers participate. Adding a WQT program will not attract the other acres unless incentives or outreach increase. If no new participants join, then WQT will simply take away some current PES participants. The results show the minimum combined N and P prices are around \$33.00 - \$46.00 but can be much higher. The results also show that the majority of the

current PES participants are “high-cost,” which is equivalent to saying the PES program is paying these farmers for very low levels of abatement. This questions whether PES money is being targeted correctly. Moreover, if policy makers anticipate simply shifting the “who pays” burden to point sources by creating WQT and deemphasizing PES, then they might be surprised that the WQT market does not highly value about one third of the participating acres and these participants might cease to do so in a WQT-only regime. The results indicate that 2% of the PES are potentially low cost procurement or more cost effective in PES. In the event WQT does generate limited activity, the highest productivity fields would potentially select into WQT because they are paid slightly more. Alternately the potential is that PES becomes even less cost effective by the highest producers of abatement leaving PES.

Limitations

The selection of fields, as opposed to farms, is a potential limitation of this work due to the choices farmers make being at farm-scale rather than a single field scale. Farmer’s choices to plant cover crops may affect some or all of the field acreage. In this study the field level was chosen due to the difficulty in accurately obtaining private information from hundreds of farms and defining the farm and field boundaries accurately using GIS.

The early planted crop payments are not within the supply curve and early planted crops offered some of the highest modeled nutrient reductions. A limitation of this study is lacking participation information on the most cost effective acres, and the assumption is the most cost effective would leave the cover crop program and enter the trading market. However, it is also an important that this data is not available

intimating that the per-acre payments, the highest offered in Maryland, do not incentivize adoption.

One of the greatest uncertainties, and also an uncertainty to which this paper contributes, is the bundling of nitrogen and phosphorous as a service. Under the cover crop program, the service of nitrogen and phosphorus reduction is purchased together and the method used herein is one potential way to analyze that bundle using cost sensitivity of three levels. There are many levels and potential ways to value the nutrients. Hopefully this is an item for further research and defining or delineating individual cost of services in PES.

CONCLUSION

Forty years have passed since the enactment of the Clean Water Act and, although much progress has been made, water quality improvement in the United States depends more than ever on reducing nonpoint source pollution. Excess nutrient runoff from agricultural fields is considered a leading nonpoint source of impairment in the Chesapeake Bay but is specifically exempted by definition in the Clean Water Act. There are many ways to address the problem of nonpoint source pollution, from more regulation, to seeking rights to restrain land use, and through developing market-based programs. This dissertation displays the result of an environmental group seeking perceived unallocated rights in the judicial and other resolution processes. The second chapter demonstrated through comparative institutional analysis methods that litigation is not necessarily the best pathway for securing disputed rights. The legislative resolution process was both fair and efficient as demonstrated by case study of *Waterkeeper v. Hudson*. The second chapter also revealed that this particular case,

while popular, was incompletely resolved, leaving potential for those further seeking unallocated rights to the land-water nexus.

There are other transaction costs and other criteria that can be used in a comparative analysis such as administration costs and costs associated with mobilization for legislative change. A broader analysis of the problem would include these different costs and criteria. However, the second chapter focused on the economic criteria of efficiency and fairness of two parties in conflict.

The third chapter was a comparative analysis of existing nutrient management planning policy and the newer nutrient trading policy. The objectives of the analysis were to examine the policy design and policy factors that affect output. The results of the comparative analysis in Maryland, Pennsylvania, and Virginia showed that participation in nutrient management planning did not increase participation in nutrient trading. The factor of an existing incentive-based policy may increase participation in nutrient trading as shown by Virginia data. Trading policy design increased monitoring cost in all states. However, Virginia also demonstrated potential to reduce monitoring costs (compared to Maryland and Pennsylvania). Virginia's policy design involves a non-regulatory approach where the farmer builds a trusted relationship with local government officials. The local government officials monitor plans, administer cost-share, and additional practices that are implemented which can include a small set of BMPs for nutrient trade. The policy design that provided the best relative potential for nutrient reduction was Virginia's design. The existing policies in Maryland and Pennsylvania are not fully compatible with facilitating an incentive based trading program. Maryland's existing regulatory regime provides monitored output in status quo, however the trading market has not developed credits

for trade. Pennsylvania's non-monitored regulatory regime has produced the most credits, but federal regulatory agencies have questioned whether the credits will be viable due to lack of monitored progress in status quo.

The fourth chapter included novel approach to analyze implications of policy interaction utilizing two incentive-based policies: PES and nutrient trading. These two policies have the same goal of reducing nutrients from agricultural producers to improve water quality. After tests for heterogeneity of nitrogen and phosphorous supply from cover crop treatments were confirmed, a simulation of potential supply curves (using sensitivity) was generated. The supply curve combined potential costs of supply for nitrogen and phosphorous as a method to include heterogeneity of services from individual fields. Results indicated that the existing PES policy has the potential to greatly impact the nutrient trading policy by establishing a price floor and could cause the market to collapse. Additionally, if the producers with the greatest nutrient reductions migrate to the nutrient trading market, PES, already suffering from ineffective payment scheme, will become less cost effective.

Comparative analysis was conducted to explore existing issues in conflict and policy to potentially inform future conflict and policy. This dissertation contributed to research by examining facets of environmental conflict caused by nutrient externalities and agricultural nonpoint source nutrient reduction policy. Environmental conflict caused by externalities can be alleviated by policy or exacerbated by policy. The future of agricultural nonpoint source policy is trending toward greater regulation at this point in time. However, while greater regulation may appease groups vying for perceived unallocated rights, it is not necessary to stimulate participation by the agricultural community. In addition, economic principles support non-regulatory

paths, however incentive and market-based measures have a host of problems including transaction costs and interactions that need to be kept in the policy makers mind.

Looking to the future of agriculture, the importance of continuing to feed increasing populations, and small likelihood of comprehensive federal regulation on nonpoint sources, private innovation holds promise. Recently, the Environmental Finance Center at the University of Maryland held a symposium to discuss how to spur private investment interest in the reduction of nutrients. Indication from investment firms was that funds were available for projects that provide socially responsible investments, including nutrient reduction. Additionally, the EPA has supported public-private partnership (P3) development that provides a framework for private investment in public problems (U.S. EPA, 2015). The U.S. EPA work groups approve technologies to incorporate into the Bay model and recently identified manure gasification as an approved technology. This and other technologies holds promise of private capital use to build regional systems that can handle excess manure and provide marketable end products like renewable energy, biochar for soil amendment, and return product to farmers such as sterile bedding (Chesapeake Bay Foundation Fact Sheet). In addition, if nutrient credits are available for manure and litter upcycling, the investment of private capital may solve funding problems currently faced by state governments to implement their watershed implementation plans.

Pennsylvania has been identified by the EPA as the integral state in achieving the Bay goals. Nicholas DiPasquale, director of the Chesapeake Bay Program office, recently expressed: “I’m going to say this as clearly as I can. If Pennsylvania does not succeed, we’re not going to succeed. It’s as simple as that” (Kobell, 2016).

Pennsylvania cites the problem of funding the implementation of their WIP. But to focus on one state, or policy, misses the bigger picture of how all the pieces fit to solve the problem. This dissertation adds to the big picture of solving nutrient excess from agriculture by providing small solutions to certain pieces such as costs of litigation and monitoring and how existing policies affect promising policies.

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Appendix A

SUPPLEMENTAL INFORMATION NUTRIENT MANAGEMENT PLANNING

Maryland's Water Quality Improvement Act

Maryland statute assigns monitoring and compliance of nutrient management plans to the Maryland Department of Agriculture (MDA). The MDA inspects plans and monitoring requirements are primarily administrative with MDA checking if plans are prepared and complete by tracking submission of annual implementation reports (AIRs). In 2014, the MDA conducted random audits (visual monitoring) of 14% of the farms which is an increase in random audits from previous years. The audits include on-farm visits to "...verify that nutrient management plans are current, examine fertilizer receipts and nutrient application records for consistency with plans, and confirm that farmers are using plans to manage nutrients effectively" (MDA 2014a). According to Maryland's Phase II Watershed Implementation Plan (WIP) submitted to EPA to demonstrate federal compliance, the Nutrient Management Act and Program is successful with estimated 99.5% compliance (based on a sample of random audits described below) and plans approved on approximately 824,729 acres out of 1,284,502 acres targeted for the 2017 interim Bay goal Maryland's Phase II (MDE, 2012). The 2014 MDA reports that 98.6 percent of the state's 5,426 agricultural operations (approximately 5,350) had submitted the required initial nutrient management plans (MDA, 2014b).

Maryland Department of Agriculture dedicates budget and human resources specifically to the nutrient management program for monitoring of nutrient management plans and technical assistance. Ten nutrient management specialist staff for inspection and enforcement are located in nine regional offices (MDA 2014a).

These staff review and conduct random audits on 5,426 facilities. Audits consist of reviewing nutrient management plans, records of fertilizer application, and fertilizer receipts. The 2014 Report to the Governor and General Assembly recognized that staff levels were too low for adequate enforcement, new (enhanced nutrient management), and fully implemented regulation (p. 11, MDA, 2014a).

An online search for specific nutrient management program budget did not result in findings of a budget line dedicated specifically to nutrient management and estimated budget is presented below. Average salaries for nutrient management specialist in Maryland are approximately \$60,000, therefore budget estimate would be \$600,000.00 per year (Indeed Maryland). If the monitoring costs are attributed to these estimates and 98.6% of operations are under nutrient management plans administrative monitoring equates to \$112 per plan per year or \$0.73 per acre ($\$60,000 \times 10 \text{ specialists} / (5,426 \text{ facilities} \times .986 \text{ with plans})$ and $(\$60,000 \times 10 / 824,729 \text{ acres})$). However, the costs are likely not evenly distributed and the bulk of time was possibly spent on the 14% (760 operations) that on-site audits were conducted.

These numbers provide a general basis for comparison to the other states and relative, general comparison to nutrient trading policy. The legislation and regulation enacted in Maryland was broad reaching and unprecedented in its impact to regulate formerly unregulated nonpoint source agriculture. The direct impact of legislation on agriculture demonstrates the political will to restrain nonpoint source pollution (Soriso, 2003). As explained in Soriso, the bill for nutrient management (SB 176) involved quick implementation and oversight by the Maryland Department of Environment (2003). The farm community supported the House version (HB 599) that involved longer compliance deadline and oversight by the MDA. The

compromise removed MDE oversight and assigned MDA with monitoring and enforcement. In sum, monitoring requirements for nutrient management plan implementation in Maryland include administrative tracking of AIRs and random on-site audits of operations and this has resulted in outcomes of (reportedly) almost 100 percent of the regulated nonpoint sources submitting plans. The MDA oversight and monitoring responsibility demonstrates a difference in approved responsibility from other states as described below.

Pennsylvania Clean Streams Law

The responsibilities of monitoring under the non-voluntary nutrient management program resides with the Pennsylvania Department of Environmental Protection (PADEP) Bureau of Conservation and Restoration which allows for voluntary (VAO) nutrient management plan implementation on all other farms (Pennsylvania Code (Act 38) 2005). The voluntary operations agree to visual inspection and administrative monitoring once per year (Brubaker and Schneider, 2009). The manure management plan compliance under the Clean Streams Law is not voluntary, however, the statute does not provision monitoring cost because the submission and tracking of the plans is not required (Pennsylvania Code 1937 as amended 1987). For the manure management plans, enforcement is complaint driven. Pennsylvania DEP will investigate a farm if a report is made regarding the farm practices. One example in recent news demonstrates how farmers are not even aware of the requirement for manure management plans (Brown, 2014). The voluntary nature of nutrient management plans and the lack of oversight in implementation of the manure management plans leaves monitoring requirements very low for PADEP.

The Pennsylvania nutrient management program is administered by the State Conservation Commission (SCC) a 14-member committee with joint members from Pennsylvania Department of Agriculture (PDA) and PADEP. The nutrient management program and SCC directs 66 county conservation districts (CCD) and 38 districts are in the Chesapeake Bay (U.S. EPA Region 3, Pennsylvania). The staff in the district offices focus on compliance under the NPDES and concentrated animal operations (Act 38) and enforcement authority is with PADEP (p. 16, U.S. EPA Region 3, Pennsylvania). As indicated, these nutrient management plans are for the point, and not non-point sources, however, there are approximately 1,189 VAOs tracked by the CCDs (p. 6, U.S. EPA Region 3, Pennsylvania). Incentives such as cost share and technical assistance have not increased voluntary participation. (U.S. EPA Region 3, Pennsylvania). Separate staff time allocated by PADEP, PDA or CCDs that track the voluntary plans alone is not available. As stated previously, manure management plans are not tracked, therefore PADEP or PDA staff time would not be devoted to this task. (p. 31, U.S. EPA Region 3, Pennsylvania). Manure management plan compliance is complaint driven and PADEP staff are permitted to randomly inspect farms for manure management plan and agricultural operations that handle manure (p 32, U.S. EPA Region 3, Pennsylvania).

It was evident in attempting to collect data on costs of manure management or nutrient management plan monitoring would result in no data comparable to Maryland because Pennsylvania administers nutrient management program and the separate manure management program, differently than Maryland. Therefore, with the current institutional design the statute is essentially complaint-driven regulation and the monitoring costs of nutrient or manure management for nonpoint source agriculture is

effectively zero. For example, one of the EPA reports on Pennsylvania's progress stated that tracking of plans was completely lacking (p. 1-3, U.S. EPA Evaluation 2014). Pennsylvania proposes to utilize conservation district staff (nutrient management technicians) to educate and inform farmers regarding their responsibilities, not monitor and track plans. In a December 2014 report, PADEP listed 38 nutrient management technicians would spend their time completing 100 on-site visits to educate farmers (p. 3, PADEP 2014-2015). The report includes 3800 visits by technicians with salary estimated at \$26,000-\$45,000 (Indeed Pennsylvania). This salary range is for technician to specialist. Assuming the 38 technicians spent the majority of their time on these visits, the lower end costs of site visits for farmer compliance education per operation costs would be \$260 per farm ($(\$26,000 \times 38 \text{ technicians}) / 3800 \text{ visits}$). Alternately, if the statute required farmer submitting manure management plans or the technicians tracked the plans, and if all animal operations using manure (estimated at 13,782 p. 31, EPA Region 3, Pennsylvania) were required to submit plans, and it is assumed the same 38 technicians were able to administratively track (no site visit) the cost per animal operation could be estimated at \$71.69 per plan ($(\$26,000 \times 38 \text{ technicians}) / 13,782$). If the average farm is 130 acres (USDA ERS) then the cost in Pennsylvania would be approximately $(\$26,000 \times 38) / 13,782 \times 130 \text{ acres}$ \$0.55 per acre. This administrative monitoring would not require on-site visits to every farm, but may entail a random audit like Maryland to determine compliance. This estimate used the technician salary because the term technician was used in the EPA report (U.S. EPA Region 3). Using specialists for education or tracking would increase the unit values due to higher salary of specialists compared to technicians.

Virginia Water Control Law

Virginia is different from Maryland and Pennsylvania and nutrient management plans are largely voluntary and incentive based conservation policies are the primary instrument used to encourage plan development. The cost share programs and best management practice (BMP) tax credits require preparation of a nutrient management plan as permit requirements or participation requirements (Sexton, nd). Under the Chesapeake Bay Preservation Act (State Water Control Law) 31 counties are designated with Resource Protection Areas (RPAs, Chesapeake Bay Preservation Area (CBPA) Designation and Management Regulation 1998). The RPA requirements are for landowners to buffer 100 feet from wetlands and waters of the state when no BMPs are used (CBPA, 1998). The buffer can be reduced to 50 or 25 feet if BMPs and nutrient management plans are in use (CBPA, 1998). Virginia is also in the process of finalizing “voluntary regulation” regarding agricultural BMPs. The Virginia’s Phase II Watershed Implementation Plan states “The resource management plan (RMP) regulations set forth specific criteria for the implementation of a suite of agricultural BMPs and will serve to promote greater and more consistent use of voluntary agricultural practices across the state. The RMP regulations, though voluntary, provide an incentive to farmers who utilize agricultural BMPs in that they will receive a ‘safe harbor’ from future mandatory requirements related to the Chesapeake Bay TMDL” (p. 3, Virginia Phase II WIP, 2012).

Nutrient management plans are not required for any other lands unless farmers are receiving cost share for the twenty approved practices, asking for tax credit for one of the six equipment categories, or fall under the point source (e.g. CAFO) permit programs (Sexton, nd). The laws governing nonpoint source pollution,

Chesapeake Bay and Virginia Waters Clean-Up and Oversight Act (2006), Water Quality Monitoring, Information and Restoration Act (1997), the Virginia Water Quality Improvement Act (1997) largely establish that waters impaired by nonpoint sources should be identified and funding established to address the sources through cooperative approaches (VADEQ Water Laws, Regulations, and Guidance). As cited on page 8 of the Nonpoint Source Pollution Management Program Plan: “NPS pollution programs require locally based remedies that address the unique, site-specific, and varied causes of NPS contaminants” (Virginia Report of the Joint Legislative Audit and Review Commission, 2005). The cooperative, incentive based, and voluntary approach is very apparent in that no state law requires nutrient management except the statutes that require permits in accordance with the federal NPDES programs.

Monitoring requirements for nutrient management planning in Virginia is administrative and/or visual with the monitoring initiated depending on the farmer’s request for reducing buffer requirements under the Chesapeake Bay Preservation Area, cost share, or tax credit. Virginia’s focus is on technical assistance and education from the Department of Conservation and Recreation, Office of Soil and Water (VADCR). Nutrient management staff train and certify plan preparers, work with local soil and water conservation districts to prepare plans, and offer other assistance in the Chesapeake Bay Preservation Act areas (VADCR). Virginia’s nutrient management program for nonpoint source agriculture is incentive based, voluntary, and flexible in nature with technical support offered by the VADCR for the nutrient management plans. In 2014, Virginia reported surpassing nonpoint source management plan goals of planning acres by 168,000 acres, with 618,000 acres as the

goal, and 786,000 acres achieved (VADEQ, 2014). The VADEQ counts acres under plans as evidence of success, but of course, as with other states, this does not mean that the farmers are actually implementing the plans.

Virginia's nutrient management program for nonpoint sources is administered under the Department of Conservation and Recreation (DCR). Virginia states in its WIP Phase II that it tracks cost share and nutrient management plans which would account for a variety of operations, point source, and nonpoint sources (p. 16, EPA Region 3 Mid-Atlantic, Virginia). However, a search for a breakdown of volunteer plans tracked did not result in findings and only acreage estimates were found (listed above). In the Chesapeake Bay watershed, the VADCR, through the Soil and Water Conservation Districts (SWCD), supports nutrient management planning and cost share with 21 staff (p. 31, EPA Region 3 Mid-Atlantic, Virginia). If it is estimated that the budget for nutrient management technicians or specialists follows salary estimates from \$28,000-\$49,000 (Indeed, Virginia) and that the plans are tracked as they administer cost share on nonpoint sources and 786,000 acres are under nutrient management, then this equates to roughly \$0.75/acre ($((\$28,000 * 21 \text{ staff}) / 786,000 \text{ acres})$) to $((\$49,000 * 21 \text{ staff}) / 786,000 \text{ acres})$ or \$1.31/acre (for specialists). If Virginia tracked plans on all 26,555 farms with livestock (USDA ERS) and the same budget human resource estimate is used, the per-plan cost would be \$22.14-\$38.75. However, if the programs are expanded more staff resources may be necessary and with a voluntary program it may not be likely that all farms would participate.

Appendix B

SUPPLEMENTAL INFORMATION NUTRIENT TRADING PROGRAMS

Maryland Nutrient Trading Policy

In Maryland, the WQIA was amended in 2010 to include a voluntary agricultural nutrient trading program (Maryland Code, Water Quality Improvement Act). Maryland did not develop regulation as a result of the statute but developed policy and guidance documents through MDE and MDA to establish nonpoint source credit generation for the agricultural community. The MDE is responsible for decisions regarding trading eligibility, credit certification, verification, and compliance monitoring and enforcement specifically for point sources and NPDES permits (MDE Policy 2008, p. 21). MDE will provide administrative review and enforce compliance of trading credits as stated in the guidance document: "The (NPDES) permits will also provide the vehicle for enforcement of the trade condition. The use of the discharge permit program will ensure that credits are accountable, reliable, and enforceable" (MDE Policy 2008, P. 8). In this guidance document MDE states that the trade verification must be followed by the trades being incorporated into the point source's NPDES permit (i.e. trade approval does not automatically incorporate the activity into the permit).

Requirements to participate in the trading market (baseline) in Maryland include practices that require administrative, visual, and modeled monitoring. The farmers must demonstrate that they have current (revised every three years with current soil testing) nutrient management plans and soil and water conservation plans (good for 10 years with no significant practice changes) (MDA Soil and Water Quality Plan Implementation) in addition to a current modeled load that meets TMDL for

nitrogen and phosphorous in lbs./ac. The process of certifying the farm for baseline includes administrative, visual (e.g. buffers, setbacks, and fencing), and modeled monitoring. Modeled monitoring is included as a monitoring category herein to describe how Maryland requires that the farm demonstrate "...level of nutrient reductions called for in the tributary strategies; or the level of nutrient reductions called for in an applicable TMDL for the watershed where the credits are generated from" (MDE Policy, 2008, p. 8). Maryland is the only state in the Bay to require this performance-based baseline. The primary method for a farmer demonstrating this requirement would be to provide current modeled load, by using a tool such as the CBNTT, or BayFast with current agronomic practice and structural input (any existing structures that control nutrients) based on their individual operation (Maryland Nutrient Trading Tool; Chesapeake Bay Facility Assessment Scenario Tool (BayFast)).

After the farmer provides information on meeting baseline, they can choose from eleven approved BMPs (thirteen more are proposed for approval) to reduce nutrients including forest buffers and animal waste management systems (MDA 2008). The policy language states that the contract between buyer and seller require allowing onsite inspection of the land generating nonpoint source credits (MDA. 2008b). This inspection may be in the form of administrative (checking if nutrient management plan is correct, inspecting fertilizer receipts) or visual (if buffers or setbacks are used). Third parties and/or MDA are required to conduct twice per year or annual onsite inspections of BMPs (depending on type of BMP) and baseline requirements annually: "All trading contracts shall require annual BMP verification and reporting. For annual practices, such as cover crops, inspections will be required a

minimum of twice during the annual life. Independent, verification by third parties is mandatory” (MDA 2008b, p. 9). The MDE is responsible for NPDES permit enforcement, and if the permit includes nonpoint source credits as part of the permit nutrient limits the point source (NPDES permit holder) maintains liability for compliance (i.e., for NPS credits, MDA 2008b).

To facilitate trades, Maryland Department of Agriculture has developed the CBNTT to calculate nutrient credits and provide a marketplace for nutrient sale. In addition, the platform will show registered credits available for sale to sources. This structure can reduce some of the transaction costs of trading, however, monitoring costs would still involve site visits, and administrative verification by MDA. A newer tool, BayFast, was developed in 2014 specifically for federal facilities then extended for use on other municipal facilities (BayFast), like CBNTT, nutrient loads can be estimated at a parcel level. Maryland does not appear to have established, functioning public, private, or nonprofit entities (clearinghouses or exchanges).

Pennsylvania Nutrient Trading Policy

Pennsylvania nutrient credit trading rules were promulgated under existing sections in the Clean Streams Law as amended (Clean Streams Law 1937 as amended 1987). The regulations developed under the statute are found under Water Quality Standards Implementation section of the Environmental Quality Board and PADEP oversees the trading program (PAEQB). Pennsylvania’s baseline for nonpoint source agriculture is defined in regulation and requires that any erosion and sediment control, manure, or nutrient management plans required by other regulation be current (PAEQB). The Clean Streams Law applies to the farms that handle or use manure, and in general, the baseline may only require manure management plan be in place

(not a nutrient management plan). In addition to the plans, at least one of three “threshold” requirements also have to be met: 1) 100-ft manure application setback, 2) 35ft. buffer, or 3) reducing nutrient application by 20 percent of the “overall amount of the pollutant reduction generated by the pollutant reduction activity the person is submitting for certification” (PAEQB 96.8 (d)(3)(C)).

To generate credits Pennsylvania farmers can choose from nine approved BMPs including cover crops, buffers, and manure gasification (PADEP Credit Generation). After PADEP certifies that the farm meets baseline, by visual or administrative review (visual would be needed of a site that selected buffer threshold) the farmer can enter the verification process. Regulations also require a verification plan that includes identifying verification process that allows for self or third party administrative and/or visual inspection of baseline and BMPs that generate credits (PADEP Credit Generation). PADEP must also be allowed to inspect for baseline and credit generating BMPs via administrative and/or visual monitoring (PADEP Credit Generation). The PADEP, under 96.8(e) Certification requirements for the Chesapeake Bay (10)(f)(2), “... may conduct other verification activities, such as monitoring and conducting inspections and compliance audits, to ensure that the pollutant reduction obligations are being met” (PAEQB). The regulations also maintain the NPDES permit holder is responsible for enforcing terms of its trade contract in a trade agreement with a nonpoint source “A permittee relying on credits to demonstrate compliance with its permit effluent limitations, conditions and stipulations under Chapter 92a shall attain and maintain compliance with its permit. A permittee is responsible for enforcing the terms of its trade contract, when needed to ensure compliance with its permit” (PAEQB section 96.8 (e)(5)).

Third party entities, both public and private, have been established in Pennsylvania to facilitate trading. Pennsylvania Infrastructure Investment Authority has partnered with PADEP to auction credits to buyers and facilitate trading in the Susquehanna and Potomac basins (PENNVEST Nutrient Credit Trading). Markit Environmental Registry and Auction website lists “forward” and “spot” auctions and states PENNVEST serves as a “central counter party and clearinghouse” and “reduces risk for buyers and sellers” to help establish a viable trading program in Pennsylvania (Markit Financial Information Services). A forward auction “means that the certified credits sold on (on a particular date) will be delivered later and applied to (future) compliance years” (PR Newswire, nd). Spot auctions involve auctioning verified credits to be used in the same compliance year (Farm and Dairy, 2014). The auction offers point sources such as “wastewater treatment plants and other regulated entities the opportunity to purchase credits to meet their nitrogen and phosphorus discharge limits for these compliance years” (Markit Financial Information Services). The buyer and seller enters into a contract with PENNVEST and seller is paid by PENNVEST after credit verification. Forward auctions have been held approximately every three months since October 2010 with the most recent forward auction on March 18, 2015 cancelled due to lack of buyer registration (Markit Financial Information Services).

Pennsylvania Department of Environmental Protection Nutrient Credit Registry website lists entities that are certified to sell or generate credits (PADEP Nutrient Credit Registry, 2014). Most facilities on the list are sewer treatment plants with a few private brokers such as Red Barn, and other nonprofits such as Berks Conservation and farmland trusts. Some of the BMPs listed that generate the credits are advanced wastewater treatment, poultry litter export, and cover crops (PADEP

Nutrient Credit Registry, 2014). As of the list date (November 14, 2014) 5,339,811 nitrogen credits and 434,572 phosphorous credits were certified from point and nonpoint sources. (PADEP Nutrient Credit Registry, 2014). The “Table Summary for 2014 Compliance Year” lists 151 trades with the majority of credits coming from waste water treatment capacity credit (or point sources) (PADEP Nutrient Credit Registry, 2014). Nonpoint source agricultural credits generated (included in the above numbers) include 299,859 certified and 106,030 verified nitrogen credits and 253 certified and 0 verified phosphorous credits (PADEP Nutrient Credit Registry, 2014).

Virginia Nutrient Trading Policy

Virginia used a different approach to implement their nutrient trading program by creating a general watershed permit program. Virginia established trading under a specific statute amending the Waters of the State Ports and Harbors Act to authorize nutrient exchange (Virginia Waters of the State Title 62.1 § § 62.1-44.19:12 through 62.1-44.19:19). The Virginia Pollution Discharge Elimination System Watershed General Permit for Nutrient Discharges to the Chesapeake Bay allows point sources to voluntarily be grouped by common ownership or operation (VADEQ 9 VAC 25 820-70 Part I.B.2) The EPA has allowed watershed-based NPDES permitting since 2003 which “emphasizes addressing all stressors within a hydrologically-defined drainage basin, rather than addressing individual pollutant sources on a discharge-by-discharge basis” (U.S. EPA Watershed-Based NPEDS Permitting). The trades are facilitated by the Virginia Nutrient Credit Exchange Association (VNCEA, Virginia Department of Environmental Quality Nutrient Credit Exchange). The purpose of the exchange is to identify certain sources that may benefit by trading with one another because of

similar geographic location. The VNCEA currently facilitates primarily point to point source trading as the voluntary membership is, at this time, consists of point sources.

To generate nonpoint source agricultural credits or offsets, baseline requirements include implementation of all applicable actions: soil conservation plan, nutrient management plan, cereal cover crops, fencing excluding livestock, vegetative buffers (VADEQ, 2008). These practices may all be new practices that the farmer implements or only some may be new. For example, the farmer may have been receiving cost share or tax credit for other practices or equipment and therefore already had a nutrient management plan, and could already have cover crops planted, then buffers may be the only requirement to meet baseline. In addition, if the field the credits are proposed to be generated on does not have livestock or a stream, the buffer and fencing would not apply to the baseline.

Farmers in Virginia have a choice of one of four BMPs to generate credits (or a combination) at present: early cover crops (Oct 5 to Nov 10 planting depending on location); 15 percent nitrogen reduction on corn; continuous no-till (5 years), and land conversion to generate credits (VADEQ, 2008). The Virginia guidance manual lists seven steps in the credit generation process. Step three requires credits and offsets be established through a broker or aggregator after VADEQ assesses progress to baseline (step one) and potential for the project to generate nutrient reductions (step two) (VADEQ, 2008). Steps four through six involve the farmer implementing practices for either baseline requirements or the credit generating project and step seven lists "authentication" as records of nutrient application, photographs of buffers and livestock exclusion, and plant/kill dates of early cover crops (VADEQ, 2008). The Virginia Watershed General Permit regulation authorizes onsite visual inspection of

the farm generating credits by point source representative, VADEQ, and third party (or aggregator).

As with Maryland and Pennsylvania, Virginia regulatory language maintains the NPDES permit holder retains liability for credit purchase. Article 4.02 of the Code of Virginia established the Chesapeake Bay Watershed Nutrient Credit Exchange Program. The final regulation was approved by the State Water Control Board at its September 6, 2006. The language within the guidance states: “It is important to realize that when you agree to generate nutrient reduction offsets for a point source discharger, you are agreeing to provide an essential compliance service to the point source. According to the watershed general permit, the point source facility owner/operator is liable under state and federal law to either maintain the discharged nutrient loads at or below their load limit or to obtain sufficient offsets to remain in compliance with the permit. To facilitate this liability, the following language has been proposed for inclusion in the permits of point source facilities that choose to trade with nonpoint sources: ‘The permittee has elected to offset any annual total nitrogen and/or total phosphorus loadings above and beyond those permitted prior to July 1, 2005, through (the acquisition of nonpoint source load reductions) or (through a proposal approved by the department that involves (insert brief summary here). Records of this acquisition shall be maintained on site (i.e., the point source facility) by the permittee and are subject to field verification by, or on behalf of, the Department. Should the reductions not be verifiable, or should they be demonstrated not to have been achieved, the permittee shall be required to obtain any additional wasteload or load reductions necessary to offset the wasteload discharged by the permittee in a given calendar year’” (VADEQ, 2008, p. 10). Contracts are between

aggregator and NPDES permit holder with little VADEQ involvement except for potential for verification inspection. The VADEQ “or an agent acting on DEQ’s behalf, may inspect the land to check records and verify the implementation of BMP enhancements or land conversion activities. These visits are to ascertain the VPDES permittee’s compliance, not yours” (VADEQ, 2008, p. 11). The guidance emphasizes the contracts for credit and offset generation are between the aggregator and the farmer and the aggregator and the point source.

Virginia legislators established the voluntary VNCEA including 73 owners of 105 treatment facilities. The exchange facilitates exchange of credits among its public and private members and is considered the “most successful water quality trading program in the United States” (VNCEA). This exchange is for point source facilities to meet their regulatory requirements cost effectively. In addition there are approximately 12 nutrient credit generating entities that also facilitate nonpoint source trading (Virginia’s nonpoint source nutrient credit registry). The Chesapeake Nutrient Land trust established in 2008 is one private firm that provides “safe harbor for development projects” through nutrient banking program. The BMPs listed are mostly “Ag land conversion” (Virginia’s nonpoint source nutrient credit registry). As of the list date (October, 2015) 4,688 nitrogen credits and 1,221 phosphorous credits were registered and available (Virginia’s nonpoint source nutrient credit registry).

Verification is added as a category to describe the additional step in monitoring nutrient trading with point and nonpoint sources. Each trading program in the states of Maryland, Pennsylvania, and Virginia contain provisions for monitoring credit development by nonpoint sources through their certification, registration, and verification processes. To verify credits would, in reality mean the ability for point

and nonpoint source contracts to reflect directly monitored abatement output (end of pipe) with other directly monitored abatement. However, with nonpoint source credits, certification and verification processes described above developed by the states, monitoring is primarily visual, administrative. Direct monitoring would entail taking soil and or water samples for analysis so verification of the actual abatement is not performed or proposed in any detail in the state's credit generation process. EPA guidance documents do suggest direct monitoring as a way to reduce uncertainty of emissions (U.S. EPA Toolkit). MDA guidance mentions direct monitoring as part of a nonpoint source credit generation process: "The Department or its agent may require more information or an on-site examination prior to approval or certification of credits. The Department will convene a Technical Panel to review and approve the Load Reduction values for some Best Management Practices. The Department *may require some additional contractual obligations and/or direct monitoring to ensure the load reductions* are met. All back up documentation shall be maintained for a minimum of 10 years" (MDA, 2008, p. 13).

Appendix C

COPYRIGHT PRIVILEGES FOR CHAPTER 2

RE: W&M ELPR Copyright Agreement

Abbott, Jan G

Jun
14

to me, Matthew

Hi, Jenny:

I'm apologize for the delay in responding. In answer to your questions, Matt and I have discussed it, and we think it is fine for you to insert the sentence at the beginning of the chapter with the appropriate attribution/notation/citation to first publication in ELPR, and it will be OK to convert to APA format.

Please let us know if you have any more questions. Thanks again for your support of ELPR and for your patience!

Jan

Jan Abbott
Journal Center Coordinator
jgabbo@wm.edu
(757) 221-3799

From: Jennifer Egan [mailto:jmegan@udel.edu]
Sent: Friday, June 10, 2016 10:15 AM
To: Keehn, Matthew <mrkeehn@email.wm.edu>
Cc: Abbott, Jan G <jgabbo@wm.edu>
Subject: Re: W&M ELPR Copyright Agreement

Matthew, (sending again to include Jan)

Thank you for getting back to me.

Two questions:

My first question is about having the entire article as the first chapter of my dissertation. I will put a sentence at the beginning of the chapter that the article was first published in ELPR. I will also put a copy of the copyright agreement as an appendix that notates non-exclusive use for the author. Is there anything else I need to add to use the article as a chapter?

Second question: I need to reformat the citations to APA and need to know if this violates any copyright? As far as I understand it will not but wanted to make sure.

Thank you!
Jenny

On Thursday, June 9, 2016, Matthew Keehn <mrkeehn@email.wm.edu> wrote:
Dear Ms. Egan,

I'm Matthew Keehn, the new Editor in Chief for ELPR, and Ross forwarded me your questions. I'm CCing our Journal Center Coordinator Jan Abbot on this e-mail, as she is well versed in these topics and I'm just getting into the swing of things. From my understanding, as for the publication credit to ELPR, it should go in the first place that the article is cited. Jan has provided an example citation format as:

Jennifer M. Egan & Joshua M. Duke, Water Quality Conflict Resolution and Agricultural Discharges: Lessons from *Waterkeeper v. Hudson*, 39 Wm. & Mary Env'tl. L. & Pol'y Rev. 533 (2015)

Please let us know if this answers your questions or if you have any follow ups, and thank you very much for your support of our journal!

Best,

Matthew Keehn

Matthew R. Keehn

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