Regulating Farmer Nutrient Management: A Three-State Case Study on the Delmarva Peninsula

Michelle R. Perez*

Abstract
Growing concern about water quality issues, along with a series of fish kills in 1997, prompted Maryland, Delaware, and Virginia to adopt regulations to reduce nutrient pollution from agricultural nonpoint sources. All three states required farmers to follow a state-certified nutrient management plan that would “optimize crop yields and minimize environmental losses,” although the policy-making processes in each state were different. The objective of this political and policy analysis research was to determine if the policy-making process affected farmer compliance and whether nutrient management practices have improved. Sixty farmers on the Delmarva Peninsula, which includes all three states, who grew corn and used poultry manure as a nutrient source were interviewed, as were 68 policy stakeholders. Analysis of state regulatory agency data indicated that the contentious policy-making process in Maryland resulted in initially poor administrative compliance (i.e., obtaining a plan), whereas collaborative approaches in Delaware resulted in very good initial compliance. Interviews with farmers indicated good adoption of four practices: possessing a current plan, taking soil and manure nutrient tests, and split-applying nitrogen fertilizer. Farmers reported poor adoption (60% or less) across all three states of other practices: taking residual nitrogen credits for previous use of legumes or manure, keeping manure-free setbacks next to surface waters, avoiding manure application in winter, and frequent calibration of manure spreaders. Although nutrient management plans were required, many aspects of implementation and enforcement meant that adherence to plans was largely voluntary. This research helped identify successes, shortcomings, and lessons learned about regulating farmers.

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Eutrophication in the Chesapeake Bay is a long-standing problem. In the 1970s and 1980s, commercially important species like shad, rockfish, and oysters experienced population collapses while underwater grasses were dramatically declining (Ernst, 2003). As early as 1983, the USEPA concluded that agricultural runoff was the primary factor causing the Chesapeake Bay’s declining health (USEPA, 1983). Agricultural nonpoint source nutrient pollution, according to Stonehouse (1997) and Favero and Abdalla (1997), is “insidious,” largely invisible, highly dependent on site variability, subject to long lag times between behavioral change and evidence in environmental outcomes, and can be ignored by farmers as environmental externalities because the negative impacts are felt by downstream users and cannot easily be traced to a specific source. Just 2 yr after the 1983 USEPA conclusion, the Chesapeake Bay Commission concluded that voluntary agricultural assistance programs would be insufficient to restore the Bay (CBC, 1985).

In 1997, a series of fish kills on the eastern shore of the Chesapeake Bay were linked to the toxic microorganism Pfiesteria piscicida and to nutrient pollution from crop and poultry production. Although largely regarded as being discredited (Belousek, 2004; Terlizzi, 2006), Pfiesteria was called “The Cell From Hell” because it was thought to be the cause of skin lesions, nausea, headaches, and short-term memory losses experienced by the fishermen and scientists who came in contact with the dead fish (Shields, 1997a,b). Of particular concern was the role that poultry manure may have had in contributing to the nutrient pollution problem in the Chesapeake Bay and its many tributaries draining the Delmarva Peninsula (land shared by Delaware, Maryland, and Virginia).

A panel convened by scientists at the University of Maryland’s Center for Environmental Science to investigate the 1997 fish kills concluded that the data linking Pfiesteria to nutrient pollution from agricultural sources, algal blooms, and fish kills were sparse. However, they also concluded that nutrient reductions might reduce the risk of future outbreaks of Pfiesteria and that such reductions also would generally be good for aquatic life, human health, and water quality (CES, 1997).

Separately, a Maryland Blue Ribbon Commission concluded that sound recommendations by the University of Maryland’s Cooperative Extension Specialists to get farmers to use poultry...
manure as a source for nitrogen (N) fertilizer rather than disposing of it as a waste product may have had some unintended consequences (Hughes, 1997). The Commission reported that soil test results indicated croplands on the Peninsula were becoming saturated with phosphorus (P) because the use of poultry manure to meet N corn crop needs resulted in the overapplication of P. The Commission also noted that although the extension specialists had encouraged control of soil erosion to address sediment-attached P from entering water ways, more recent science suggested that P could run off in a dissolved form even if soil erosion was controlled. The Commission observed that neither of these emerging scientific concerns had been formally conveyed to farmers and thus regarded the fish kill events as a policy window of opportunity to do so (Hughes, 1997).

The long-standing policy in all three states for reducing agricultural sources of water pollution was to implement voluntary financial and technical assistance programs to assist willing farmers to adopt nutrient management, manure management, and soil erosion control practices. The human health scare associated with the fish kills served as a focusing event and turned the media spotlight on the voluntary approach. Policy leaders in Maryland, followed by Virginia and then Delaware, concluded that the voluntary approach was inadequate for addressing the long-standing nutrient pollution problem and the new *Pfiesteria* problem.

All three states decided to require farmers to obtain and follow nutrient management plans that “optimized crop yields and minimized environmental losses.” The plans established an average yield goal for each crop based on the average of the best 3 out of 5 yr, prescribed N and P application rates, and required various other nutrient management practices.

The literature on factors that influence farm compliance with regulatory requirements is thin given that very few federal and state regulations exist (ELI, 1997; ELPC and MRC, 2010; Perez et al., 2009). Assessments of how well agricultural regulations are implemented and enforced or what their environmental outcomes have been are even more sparse. A few studies suggest that the water quality-related agricultural regulations tend to be limited in the number of farmers they affect and the behavioral changes they require, difficult to implement and enforce, and rarely monitored for environmental outcomes (ELI, 2000; Perez et al., 2007). Ferguson (2015) and Exner et al. (2010) have reported that N regulations in the Central Platte Valley in Nebraska for irrigated crop fields enacted in 1988 have been successful at lowering groundwater nitrate contamination (1988–2012); during this period corn yields have risen, indicating a win-win regulatory situation.

The literature on factors influencing farmer adoption of environmental best management practices or participation in voluntary conservation programs is extensive. However, a review of 55 studies spanning 25 yr by Prokopy et al. (2008) indicates that much remains unsettled regarding the strongest predictors of practice adoption. Twelve out of 20 studies found that access to information had a positive influence on the decision to adopt. Ribaudo and Horan (1999) found that farmers have to believe that a problem exists before they accept that best management practices are justified and are willing to take action. Feather and Cooper’s (1995) review of USDA’s conservation programs determined that the impact on farm profitability was the most important factor influencing farmer decisions to participate in programs and to adopt practices that reduce water pollution.

The 1997 fish kills focusing event provided conditions akin to a natural experiment for a three-state environmental policy case study on the effectiveness of requiring nutrient management plans for reducing farm nutrient pollution (Perez, 2010). Because three states responded to the same event in some similar ways but had mostly different policy deliberation processes, regulatory requirements, implementation schedules, and enforcement efforts, the objective of this research was to determine if the state policy-making processes affected compliance with the laws.

### Materials and Methods

This study addressed the following research questions: (i) Did the policy process to develop nutrient management regulations in response to the 1997 *Pfiesteria* events in Maryland, Virginia, and Delaware affect farmer compliance? and (ii) Have these laws resulted in improved nutrient management practices by farmers on the Delmarva Peninsula? Farmer compliance was defined as both “administrative” compliance (i.e., possession or submission of the required plan and/or annual reports) and “adherence” compliance (i.e., following the nutrient application recommendations in the plan or other required best management practices). To find answers to the questions, a historical, three-state comparative case study using political and policy analysis was conducted. The approach combined quantitative analysis of in-person surveys and state regulatory compliance data with qualitative analysis of anecdotal quotations so as to effectively illustrate the quantitative findings.

Eight years of regulatory compliance data from each state was obtained from 2001 to 2008. Sixty-eight policy stakeholders were interviewed from 2005 to 2009 representing state and county nutrient management programs, state departments of agriculture and environment, university science and economics departments, farm trade associations, environmental organizations, elected officials, and private crop consulting firms. Stakeholder interviews were both in-person and over the phone and were recorded with consent.

Sixty farmers on the Delmarva Peninsula were interviewed during 2005 and 2006. All farmers grew corn and used poultry manure. The number of farmers interviewed was largest for Maryland (*n* = 30); fewer farmers were interviewed from Delaware (*n* = 20) and Virginia (*n* = 10), reflecting the order among these states of the number of farmers regulated on the peninsula. Five of the study’s Virginia farmers were unregulated by their state law because they did not raise chickens. Study recruitment occurred by randomly meeting farmers at farm trade association annual meetings, trade shows, state agricultural events, and nutrient management meetings sponsored by the states, the counties, and the private sector. The “snowball sampling” method was used to identify additional farmers by asking the initial farmers to recommend others who met the eligibility criteria (Kelley et al., 2003). Interviews were conducted in person and were recorded with consent. Interviews lasted an average of 1.5 h. Farmer identities were kept confidential, and their responses were kept anonymous.

Farmers were asked about their farm characteristics, poultry manure management and manure use practices, commercial fertilizer application rates on corn, other nutrient best management practices, and their awareness of various nutrient management and
nutrient pollution issues. Farmers also filled out a 26-statement Likert Opinion questionnaire developed to quantify their attitudes and opinions on a comparable scale, with five answer choices ranging from “strongly agree” to “strongly disagree” (Clason and Dormody, 1994). The Likert statements elicited farmer opinions on the problem diagnosis of the *Pfiesteria* events; the role of farmers, poultry growers, and poultry integrators (e.g., Perdue Farms, Tyson Foods, etc., who contract with poultry growers to raise the chickens to market-ready weight) in solving the nutrient problems; the state policy development process; implementation of the regulatory programs; the regulatory requirements and their likelihood of compliance; and their understanding of nutrient and environmental science. There was no statistically significant difference between the average age of farmers interviewed in each state or their farm acreage. However, the interviewed farmers were, on average, a few years younger than the average age of the “principle operators” in each state according to the National Agricultural Census and, on average, operated larger farm acreage than the Census average. The quantitative data generated during the farmer interviews were analyzed with two statistical methods. Descriptive statistics were used to determine if there were statistically significant differences between states for continuous variables, such as age and farm acreage. Categorical variables (e.g., the responses to the Likert Opinion statements and yes-no answers to questions about nutrient management practices or answers with more than one category) were analyzed for statistical significance using the Fisher exact test method for contingency tables. This method is appropriate for small

Table 1. Summary of key policy-making process elements in each state.

<table>
<thead>
<tr>
<th></th>
<th>Maryland</th>
<th>Delaware</th>
<th>Virginia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political style</td>
<td>contentious</td>
<td>collaborative</td>
<td>negotiated</td>
</tr>
<tr>
<td>Chesapeake Bay</td>
<td>very strong</td>
<td>limited</td>
<td>limited</td>
</tr>
<tr>
<td>environmental culture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem diagnosis</td>
<td>burdened with diagnosing <em>Pfiesteria</em></td>
<td>skipped diagnosis</td>
<td>took a “go slow” approach</td>
</tr>
<tr>
<td></td>
<td>dominated by environmental stakeholders and internal pressures</td>
<td>dominated by agricultural stakeholders and external pressures</td>
<td>agricultural stakeholders had an edge; motivated by internal pressures</td>
</tr>
<tr>
<td>Policy deliberations</td>
<td>Maryland Department of Agriculture</td>
<td>Delaware Nutrient Management Commission</td>
<td>Virginia Department of Conservation and Recreation and Virginia Department of Environmental Quality</td>
</tr>
<tr>
<td>Regulatory agency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requirements</td>
<td>“all” farmers need plans + 4 practices (eligible farmers† started at 16,000; in 2008: 5902)</td>
<td>“all” farmers need plans + 2 practices (eligible farmers started at 6775; in 2008: 1158)</td>
<td>poultry growers§ need plans + 8 practices (eligible growers started at 1309; in 2008: 894)</td>
</tr>
<tr>
<td>Educational requirements for persons applying nutrients</td>
<td>6-h nutrient application training every year</td>
<td>6 h continuing education every 3 yr for private nutrient handlers; 9 h/3 yr for commercial handlers</td>
<td>none</td>
</tr>
<tr>
<td>Requirement for poultry integrators</td>
<td>required to use phytase in chicken feed to lower the manure P content and pay 50% of manure transport program</td>
<td>support growers to comply with the law through technical and financial assistance</td>
<td></td>
</tr>
<tr>
<td>Phosphorus-poultry manure policy</td>
<td>Phosphorus Site Index required on fields with “excessive” P Fertility Index Values</td>
<td>3-yr P crop removal policy</td>
<td>three options: a 3-yr P crop removal policy; a PSI; a P Environmental Threshold depending on three regions and soil test P results</td>
</tr>
<tr>
<td>Implementation schedule</td>
<td>first deadline 3.5 yr after law enacted caused major implementation problems</td>
<td>first deadline 3.5 yr after law enacted, but only 20% had to comply each year over 5 yr; was easily implemented</td>
<td>first deadline nearly 3 yr after law enacted; was easily implemented</td>
</tr>
<tr>
<td>Cost-share available</td>
<td>for nutrient management plans and for manure transport</td>
<td>for nutrient management plans but very limited support for manure transport</td>
<td></td>
</tr>
<tr>
<td>Enforcement approach</td>
<td>all three states used a “compliance assistance” approach “to bring farmers into compliance” and rarely levied penalties</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

† “Eligible farmers” refers to the farmers who met the criteria established by each state law as needing to obtain a nutrient management plan and comply with the law. Maryland required that any agricultural operations with more than $2,500 gross annual income or eight animal units must comply with the law, Delaware’s law applies to any person or firm that operates an animal feeding operation in excess of eight animal units or that applies nutrients to more than 10 acres of land (e.g., golf courses, turf and recreational facilities, and lawn care companies).

‡ 2008 was the last year state regulatory agency data was reviewed.

§ Virginia poultry growers with more than 20,000 chickens or 10,000 turkeys were required to obtain a Virginia Pollution Abatement permit.

**Results**

**State Regulatory Policy-Making Processes**

In response to the 1997 *Pfiesteria*-related fish kills in the Chesapeake Bay, Maryland enacted the 1998 Water Quality Improvement Act, Delaware passed the 1999 Nutrient Management Law, and Virginia passed the 1999 Poultry Waste Law. The policy-making processes in the three states were mostly different regarding state political styles, strength of Chesapeake Bay environmental culture, problem diagnosis, and policy deliberations. These factors influenced which farmers the states decided to regulate and what they required the farmers to do, what the poultry integrator companies were required to do, what P management policy was established, the regulatory implementation schedules, the financial assistance provided to comply, and the enforcement efforts (Table 1).

**Maryland’s Policy-Making Process and Comments from Farmers and Stakeholders**

Maryland’s approach to developing agricultural nutrient management requirements generally fit the “enforced” regulatory
style described by Shover et al. (1986) as having a rigid and comprehensive statute formation, an adversarial and formal rule-making process, regulations that are legalistic and have detailed design standards, and a stringent application of the rule.

Maryland has a very strong Chesapeake Bay culture; half of the Bay's upper reaches lap against Maryland shores, and 90% of the state's landmass is in the Bay watershed. Because most of the fish kills occurred in Maryland waters, Maryland policy stakeholders were burdened with problem diagnosis and had to operate under the very hot media spotlight. In response to state medical experts' concerns that the fish kills were possibly affecting human health, the government closed several affected rivers to swimming, boating, and fishing, which caused economic hardship in the state's many water recreational and seafood businesses (Babington and Shields, 1997). "Pfiesteria hystrix" became a catch phrase as the Washington Post and the Baltimore Sun began what some described as a horse race to cover the story (Finchman, 2007).

Farmers interviewed in the present study deemed media coverage linking Pfiesteria and nutrient pollution to farming and poultry production to be inflammatory and divisive. Farmers expressed concern about the viability of their livelihoods when members of the Blue Ribbon Commission and then representatives of the General Assembly (who wrestled over three legislative proposals) debated options to (i) make nutrient management plans mandatory, (ii) place a moratorium on the construction of new poultry grower houses on the Peninsula, and (iii) make the poultry integrators jointly responsible for the manure with the poultry growers. During six of the seven Nutrient Management Public Hearings held by the Maryland Department of Agriculture in 2000, Paulisso and Maloney (2000) observed that, "Farmer perception that the regulations are unjust, personally hurtful, and senseless—in effect violating their moral code—has created much animosity and anger within the farming community toward the regulations and those who are seen as supporters of it."

One farm trade association stakeholder from Maryland in the present study summed up the overall feeling expressed by most interviewed farm stakeholders and farmers in the state: "Agriculture was in a defensive mode from the day it started till the day it ended. They looked on us as criminals." Another farm trade association stakeholder said in an interview, "It was war. The rhetoric was so ferocious; there was no discussion." Regarding farmer opinions about their state's policy-making process, the majority of farmers from Maryland felt ostracized by the policy-making process, with one saying, "We didn't have no fair say in it. All the meetings I went to (in Salisbury), any time a farmer tried to say something, they didn't want to hear it. They would just disagree. It seemed like we were beaten before we ever talked."

Although the Maryland Department of Environment (MDE) was initially discussed as the agency to implement the regulatory program, many in the agricultural and environmental communities objected, pointing out that the MDE specialized in point sources of pollution and knew little about agriculture or farmers. Although the Maryland Department of Agriculture initially objected to being made the regulatory agency, they acknowledged they would be better suited than the MDE. Despite this reasoning, Maryland policymakers were criticized as "allowing the fox to watch the henhouse" (Meyer, 1997).

Delaware's Policy-Making Process and Comments from Farmers and Stakeholders

At the other end of the spectrum, Delaware's approach to developing its farm nutrient management regulations largely reflected Shover et al.'s (1986) "negotiated" regulatory style, which has a flexible statute formation process, a negotiated rule-making phase, regulations that are discretionary and have broad performance standards, and an accommodative and conciliatory rule application.

The Chesapeake Bay culture in Delaware is limited given the state has no Bay waterfront, although one third of the state does drain into the Bay watershed. Therefore, Delaware largely avoided having to diagnose the fish kills in the Bay, largely deferring to the investigative efforts in Maryland and Virginia.

In response to the pressure the state was receiving from Maryland and Virginia to develop a regulatory response to the Pfiesteria-related fish kills, the state government set a calm and cooperative tone by delegating the policy discussion first to a group of influential farmers and then to administrative agencies. Environmental policy stakeholders pointed out that Delaware did not have a voluntary nutrient management program like Maryland and Virginia had developed a decade earlier; nor was Delaware in compliance with the USEPA's requirements to develop a regulatory confined animal feeding operation program. A 10-farmer advisory committee was formed to provide recommendations to the General Assembly, and the Chair of the House Agriculture Committee drafted legislation that satisfied the concerns of the agricultural industry.

Delaware decided that neither the Department of Agriculture nor the Department of Natural Resources and Environmental Control should be tasked as the regulatory agency to write the regulations, implement the program, and ensure enforcement. Instead, Delaware resurrected its defunct commission system and created a new quasi-governmental agency, the Delaware Nutrient Management Commission. Seven of the 15 voting seats on the Commission were reserved for full-time farmers, two were for representatives from environmental groups, and the rest of the seats were for various agricultural interest groups (e.g., nutrient consultants, nutrient applicators, etc). Nonvoting members of the Commission included representatives from the Delaware Department of Agriculture, the Department of Natural Resources and Environmental Control, and the University of Delaware Cooperative Extension Service.

Much of the policy deliberations in Delaware occurred in informal meetings rather than in the media spotlight. One environmental agency stakeholder from Delaware said, "We realized early on that we had to deal with farmers—meet them at the table, listen to them, involve them in the process... If we had taken a strident regulatory position, we would have been defeated in 2 weeks." "The smartest thing we did in our lives was to tailor the bill to accommodate the farmers' needs... The people involved in the early construction of the law turned out to be smart as hell and good farmers... Of course, we still had screaming and yelling and stomping out of the rooms at different times on both our parts... But, I think we each earned each other's respect." Comments from farmers in Delaware underscored that they appreciated their state taking a collaborative approach: "They're trying in Delaware to work with the farmer as much as possible. Not this overbearing
very heated at times. There was a point, we were considering
involved: enviros, state agencies, the poultry industry. It got very,
decide the regs took a very long time. There were over 30 people
But the Nutrient Management Advisory Commission process to
gathering and not making decisions off the tops of our head…
One environmental stakeholder said, “There was a lot of data
process, akin to the experience of farm groups in Maryland.
Half of Virginia’s landmass drains into the Chesapeake Bay
watershed, and one third of the lower section of the Bay is within
Virginia territory where many commercial fisheries, industrial
port cities, ship-building yards, and military installations are
located. The media categorized the Virginia state government’s
response to the *Pfiesteria* fish kills as “a go-slow approach,”
which greatly relieved the seafood industry because they saw the
the law occurred during the regulation writing phase. The DEQ
decided not to extend the law’s nutrient management
requirements to crop farmers who only used manure from
poultry growers but were not poultry growers themselves. In
its explanation, DEQ echoed arguments made by the farm trade
associations that requiring tracking of the litter off the poultry
farm would destroy the existing market for poultry manure.
This limitation disappointed environmental stakeholders, who
pointed out that three fifths of the poultry manure was estimated
to be transported off the generating poultry farms for use by
nonpoultry growers and that up to 80% of the manure might
be moved off-farm when the phosphorus management policies
took effect (Edwards, 1999).

Interviews with representatives from the environmental
stakeholders for the present study suggest that the environmental
groups in Virginia felt disempowered by the policy-making
process, akin to the experience of farm groups in Maryland.
One environmental stakeholder said, “There was a lot of data
gathering and not making decisions off the tops of our head…
But the Nutrient Management Advisory Commission process to
decide the regs took a very long time. There were over 30 people
involved: enviros, state agencies, the poultry industry. It got very,
very heated at times. There was a point, we were considering
walking away from the table—we felt weren’t being heard and
were out negotiated by the poultry industry.”

**Virginia’s Policy-Making Process and Comments from Farmers and Stakeholders**

Virginia’s policy process more closely reflected the “negotiated”
regulatory approach described by Shover et al. (1986), making it
closer to Delaware’s approach than to Maryland’s. Like Delaware,
most of the policy-making occurred behind closed doors and out
of the media spotlight.

The Poultry Waste Law was enacted in January 1999 to
bring the poultry industry on parity with existing regulations of
the state’s largest dairy and swine farms. The law required the
Department of Environmental Quality (DEQ) to extend its
Virginia Pollution Abatement permit program to poultry growers
and tasked the Department of Conservation and Recreation
to extend its technical assistance on nutrient and manure
management to implement the program. Several modifications
to the law occurred during the regulation writing phase. The DEQ
decided not to extend the law’s nutrient management
requirements to crop farmers who only used manure from
poultry growers but were not poultry growers themselves. In
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**State Regulations**

**Regulatory Universe and Requirements**

Maryland decided that “all” farmers in the state needed to
obtain and follow a nutrient management plan and required four
additional practices: taking soil tests at least every 3 yr, taking residual
N credits for legumes or manure, taking manure tests at least every
2 yr, and not applying manure in winter months. Maryland, like the
other two states, had a difficult time identifying the farmers deemed
eligible for coming into compliance with the law. The state started
with 16,000 farmers, but in 2008 (the last year state regulatory
data was reviewed) only 5902 were determined to be eligible (Table
1). Delaware also decided that “all” farmers needed plans and
required two extra practices: taking soil tests at least every 3 yr and
taking residual N credits for legumes or manure. Eligible farmers
in Delaware started at 6775, but this number decreased to 1158 in
2008. Virginia required a nutrient management plan for poultry
growers that also grew crops and a manure management plan for
poultry growers that did not grow crops. Eight additional practices
were required: taking soil tests at least every 3 yr, taking residual N
credits for legumes or manure, taking manure tests at least every
3 yr, using the PSNT or stalk test, split applying fertilizer, calibrating
manure spreaders every year, keeping manure-free setbacks from
ditches or streams, and not applying manure in winter months.

Eligible growers started at 1309, and in 2008 they numbered
894. Maryland and Delaware required continuing education
requirements. For persons applying nutrients, Maryland required
6 h of certification classes every year while Delaware required 6 h
of continuing education every 3 yr for all private nutrient handlers
and 9 h every 3 yr for commercial handlers. Virginia’s law did not
prescribe any educational requirements.

**Regulatory Implementation Schedule**

All three states required their eligible farmers to obtain a
state-certified nutrient management plan within 3 to 3.5 yr after
the laws were enacted. However, Delaware divided its regulated
farmer community into fifths and required only one fifth of the
farmers to comply each year over 5 yr. According to one Delaware
policy stakeholder, Delaware provided this accommodative,
extended regulatory program period to avoid inundating the
state-certified private crop consultants with farmers needing
plans all at once. This also helped to spread out the “new business”
that the law created for the private consultants. Environmental
policy stakeholders in Maryland complained to the media that
the 3-yr implementation schedule was too slow, but interviews
with members of the scientific community in Maryland revealed
how challenging it was to meet that deadline because they had to
(i) come to consensus on the updated dissolved P science,(ii) establish a Phosphorus Site Index (PSI) that identified fields
at risk for P loss, (iii) develop new nutrient management plan
writing software to reflect the new science, (iv) develop outreach
materials, (v) establish certification standards, and (vi) train
hundreds of public- and private-sector individuals to write the
plans. For the regulatory agencies, they were overwhelmed with
the task of determining and identifying which farmers to hold
accountable for getting a plan, follow the regulations, and attend
the required educational events.
Poultry Integrator Requirements

The role of the poultry integrator companies was hotly debated in the media in Maryland because the companies objected to being held responsible for the poultry manure generated by the chickens. The companies successfully argued that even though they owned the chicks, it was the poultry growers who wanted the manure for use as fertilizer and thus the manure was the growers’ responsibility. Maryland’s law did require the integrators operating in the state to (i) use the enzyme phytase in the chicken feed, which enabled the integrators to lower the amount of P they added to the feed, thereby reducing the amount of P in the manure, and (ii) pay 50% of state-sponsored manure transport program. Delaware and Virginia laws only required the integrators to support their growers to comply with the laws through technical and financial assistance. Once the integrators in Maryland saw that adding phytase to the chicken feed lowered their costs of adding P, they adopted the practice in their operations in Delaware and Virginia.

New P Policy

Rather than solely relying on a soil P concentration test, Maryland’s law required development of a sophisticated PSI and required its use during the preparation of the nutrient management plans on fields with “excessive” soil Fertility Index Values. The PSI uses soil P test information, but, on a field-by-field basis, it rates the potential for P movement by assessment of the each field’s site characteristics and current management practices. At the “very high” PSI rating, no additional P (poultry manure or commercial fertilizer) was allowed, and remediation practices were required to lower the P loss potential from the site. In contrast, Delaware opted to make the PSI optional to give time to their soil scientists to develop a PSI and because conducting the PSI in each farm field takes planners an appreciable amount of time. Delaware selected a 3-yr P crop removal policy to be used as a default when a soil test rates the P concentration as “high.” This allowed farmers to continue applying poultry manure or commercial P fertilizer at rates that would be taken up by crops at harvest within the 3-yr rotation. According to interviews with Delaware soil scientists, this approach keeps the P in an equilibrium state in the soil, whereas Maryland’s PSI rule draws down the excess P in the soil over time. Virginia’s law prescribed the development of a P policy but set an early default of “phosphorus application rates shall not exceed the greater of crop nutrient needs or crop nutrient removal.” By 2005, Virginia provided farmers with three management options; soil test recommendations for commercial fertilizer users; and, for manure users, the PSI or an environmental threshold approach, which established the maximum P application rates for three agricultural regions in the state according to three soil test P results. Most Virginia farmers opted for the threshold approach, which usually meant use of manure at a 3-yr crop removal rate and then a discontinuation of manure application at very high soil test P results.

Financial Assistance Programs

Recognizing the impact the new P policies would have on many farmers and especially those with excess manure, Maryland and Delaware developed financial assistance programs to help farmers comply with the regulations. Maryland developed a manure transport program paid for in part by the state’s poultry integrators. Delaware also established a nutrient relocation program paid for solely by the state. Perdue Farms built a poultry litter pelleting plant in Delaware to take excess manure from poultry growers contracting with Perdue in all three states on the Peninsula and turn it into fertilizer pellets for use by golf courses and other industries. Virginia’s manure transport program never got off the ground due to an informal market for manure already in place.

Maryland provided cost-share to farmers so they would be able to hire state-certified planners from the private sector (e.g., fertilizer dealers, crop consultants, seed suppliers, etc.) and take soil tests, but only a fraction of the regulated farmers were able to obtain the limited cost-share before it ran out every year. Maryland also provided a tax credit to farmers to help purchase commercial N if their plan forced them to stop using manure or to lower their manure rates and provide a tax deduction for modern manure spreaders capable of achieving a one ton/acre manure application rate. Delaware provided more generous “cost-share” by covering 100% of the costs to hire a private planner and to take the soil tests. Virginia did not provide cost-share funds for these costs.

Enforcement Approach

One important common factor between all three states was their “compliance assistance” approach to detected violations. This approach emphasized informal and educational efforts and working one-to-one with farmers to “bring the farmer into compliance,” as opposed to formal enforcement procedures. None of the state laws called for large fines for noncompliance, and penalties were rarely levied.

Answers to Research Question 1: Did the Policy Process Affect Farmer Compliance?

To answer the first research question, several datasets were collected, including (i) state agency compliance data, (ii) Likert opinion statements, (iii) self-reports of compliance with or adoption of nutrient management practices, and (iv) farmer interview comments about compliance.

State Regulatory Agency Compliance Data

Overall, it was very difficult to determine compliance with each state’s law because the data provided by the states were limited and hard to interpret. Despite these challenges, the state compliance data suggest that the policy-making process did affect compliance (Table 2). The contentious policy-making process in Maryland did appear to negatively affect administrative compliance in the early years of implementing the law, whereas the collaborative policy-making process in Delaware did appear to result in very good compliance rates in the first few years.

However, the data indicated the outcomes flipped in 2008, the final year of this case study’s review of the state agency data. By then, most Maryland farmers were in compliance with having a plan and also filing two-page annual implementation reports, whereas 30% of acreage in Delaware still had not been covered by a plan and the Delaware Commission continued to avoid publishing farmer compliance rates (instead reporting only number of acres in compliance). Furthermore, only a third of the expected annual implementation reports in Delaware were being submitted. In Virginia, administrative compliance was practically perfect at both the initial compliance period and the...
later time frame, reflecting the reality that the majority of newly regulated poultry growers did not need a nutrient management plan but only needed a simple manure transfer plan because they did not grow crops.

Many farmers and stakeholders said in interviews that Maryland farmers reacted very poorly to what they perceived as an unfair policy-making process by “digging in their heels” and refusing to obtain a plan. As the compliance deadline drew near, Maryland was forced to offer “Justification of Delay” forms, which allowed farmers to demonstrate that they at least tried to make an appointment with an extension specialist to develop their plan and could not get one because the public planners were so overloaded with late requests. Several nutrient management specialists and state program administrators said they believed farmers were taking advantage of the Justification of Delay forms by filing them for many years in a row to delay coming into compliance with the law.

None of the states fulfilled the four elements of deterrence identified by Charlton (1985) as critical to a state agency trying to prevent noncompliance: (i) a credible likelihood of detection of the violation, (ii) swift and sure enforcement response, (iii) appropriately severe sanction, and (iv) perceiving each of these actions as real. For example, farm inspection goals for Maryland and Delaware were set at just 10% per year, and the procedures for determining if the farmer was applying nutrients at rates other than specified in his plan involved a review of available records (soil and manure test results, fertilizer receipts, manure transfer receipts, granary receipts) and simple mathematical calculations, making it very difficult to detect and prove noncompliance.

Regarding the threat severe sanction, in reaction to the Likert Opinion statement, “The penalties for non-compliance with my nutrient management law are... [large, moderate, don’t know, small, nonexistent],” half to 60% of farmers in all three states selected the response option “don’t know.”

Despite setting a 10% per year on-farm inspection goal, Maryland came close with 8%, whereas Delaware only achieved a 2% inspection rate (Table 2). Virginia came very close to their 100% inspection goal. Regarding adherence compliance rates reported by each state regulatory body, Maryland had the lowest rates, with approximately 35% of inspectors in noncompliance with the law. Only about a fifth of Delaware and Virginia farmers were deemed noncompliant.

Likert Opinion Statements

All five Likert opinion statements in Table 3 showed statistically significant differences between states at the 90% confidence level, providing further evidence that the policy-making process likely affects compliance, with most Maryland and Virginia farmers feeling negative about their state law and plans and most Delaware farmers feeling positive about them.

Most farmers from Maryland and Virginia (i) disagreed that “farmers had an equal seat at the policy-making table,” (ii) disagreed that their “law is justified,” (iii) agreed that “current agricultural nutrient management regulations are stricter than they should be,” (iv) agreed that “the nutrient recommendations in my plan are too conservative,” and (v) disagreed that “I would be satisfied with my crop if I strictly followed plan.” Most Delaware farmers held the opposite views. This research posits that the level of satisfaction farmers feel about their state laws and their nutrient management plans may indicate the level of adherence to the plans.

Compliance with or Adoption of Nutrient Management Practices

Because each state required different practices, comparing compliance rates among the interviewed farmers was a concern. However, this case study deemed it appropriate to analyze farmer implementation of practices regardless of whether the practices were mandatory given the mandated practices had long been encouraged by all three states’ extension specialists and district conservationists as best practices. Compliance or adoption rates that were 60% and higher were considered to be “good,” and rates that were below 60% were deemed “poor.”
It appears that farmers were more alike than they were different when reporting their use of these required or voluntary best management practices (Table 4). In contrast to the first two datasets, these data suggest that the answer to the first research question should be “no” (i.e., the policy-making process did not have a statistically significant impact on adherence compliance or voluntary adoption of these practices). Regardless of state, implementation rates were only good (60% or more) for four practices required by at least one state: (i) they did have current nutrient management plans, (ii) they were taking soil and (iii) manure tests at least every 3 yr, and (iv) they were split-applying commercial N fertilizer (rather than applying it all at once, which increases the risk of environmental losses).

Regarding the nutrient management practices that were poorly implemented (below 60%) across all three states, most farmers were (i) not taking residual N credits and thus were overapplying N; (ii) likely getting poultry manure in surface waters because they were driving manure spreaders too closely to ditches or streams; (iii) disposing of manure by applying it during winter months when no crops could absorb the nutrients, risking significant environmental losses; and (iv) not calibrating manure spreaders at least annually and thus were likely not applying the manure rate they thought they were applying given the tremendously variable moisture and nutrient content of manure generated by different poultry houses.

**Interview Comments about Compliance**

When the question, “Are you following your nutrient management plan?” was asked, several farmers objected, saying with a smile, “You can’t ask that!” Extension specialists cautioned that such a question suffers from the social desirability problem wherein the interviewee knows what the societally appropriate answer should be or what the interviewer wants to hear. Although very few farmers provided a direct answer to the question, 36 of the 55 regulated farmers provided at least one comment during

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### Table 3. Responses to Likert Opinion statements indicating differences in farmer opinion about their state’s policy-making process and their required nutrient management plans.

<table>
<thead>
<tr>
<th>Number of farmers by state‡</th>
<th>Agree</th>
<th>Don’t know</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>تركيبة</strong></td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maryland (n = 30)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmers had an equal seat at the policy-making table in my state during the development of the nutrient management law and regulations (p = 0.000***).</td>
<td>13</td>
<td>13</td>
<td>73</td>
</tr>
<tr>
<td>My state’s agricultural nutrient management law is justified (p = 0.002***).</td>
<td>40</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>Current agricultural nutrient management regulations in my state are stricter than they should be (p = 0.000***).</td>
<td>79</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>The nutrient recommendations in my nutrient management plan are too conservative (p = 0.000***).</td>
<td>67</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>If I were to strictly adhere to the application recommendations in my nutrient management plan, I would likely be satisfied with the crop I harvest (p = 0.005***).</td>
<td>27</td>
<td>0</td>
<td>73</td>
</tr>
<tr>
<td>DE (n = 20)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmers had an equal seat at the policy-making table in my state during the development of the nutrient management law and regulations (p = 0.000***).</td>
<td>65</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>My state’s agricultural nutrient management law is justified (p = 0.002***).</td>
<td>60</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Current agricultural nutrient management regulations in my state are stricter than they should be (p = 0.000***).</td>
<td>20</td>
<td>15</td>
<td>65</td>
</tr>
<tr>
<td>The nutrient recommendations in my nutrient management plan are too conservative (p = 0.000***).</td>
<td>80</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>If I were to strictly adhere to the application recommendations in my nutrient management plan, I would likely be satisfied with the crop I harvest (p = 0.005***).</td>
<td>60</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>VA (n = 10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmers had an equal seat at the policy-making table in my state during the development of the nutrient management law and regulations (p = 0.000***).</td>
<td>0</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>My state’s agricultural nutrient management law is justified (p = 0.002***).</td>
<td>20</td>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>Current agricultural nutrient management regulations in my state are stricter than they should be (p = 0.000***).</td>
<td>80</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>The nutrient recommendations in my nutrient management plan are too conservative (p = 0.000***).</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>If I were to strictly adhere to the application recommendations in my nutrient management plan, I would likely be satisfied with the crop I harvest (p = 0.005***).</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*** Significant at the 0.001 probability level.
† Statistics refer to differences between states.
‡ DE, Delaware; MD, Maryland; VA, Virginia.

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### Table 4. Summary of self-reported farmer compliance (or voluntary adoption) rates of nutrient best management practices in each state.

<table>
<thead>
<tr>
<th>Required by</th>
<th>Requirements</th>
<th>Compliance rates†</th>
<th>Statistical significance‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>All three states</td>
<td>Possess a current nutrient management plan.</td>
<td>Maryland (n = 30)</td>
<td>Delaware (n = 20)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>All three states</td>
<td>Take soil tests at least every 3 yr.</td>
<td>77</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>73</td>
<td>95</td>
</tr>
<tr>
<td>All three states</td>
<td>Take residual N credits for legumes or manure.</td>
<td>–20</td>
<td>–20</td>
</tr>
<tr>
<td>Virginia</td>
<td>Take manure tests at least every 3 yr.</td>
<td>60</td>
<td>95</td>
</tr>
<tr>
<td>Maryland</td>
<td>Take manure tests at least every 2 yr.</td>
<td>43</td>
<td>65</td>
</tr>
<tr>
<td>Virginia</td>
<td>Use the PSNT or stalk test.</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>Virginia</td>
<td>Split apply fertilizer.</td>
<td>80</td>
<td>85</td>
</tr>
<tr>
<td>Virginia</td>
<td>Calibrate manure spreaders every year.</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Virginia and Maryland</td>
<td>Keep manure-free setbacks from ditches or streams.</td>
<td>37</td>
<td>20</td>
</tr>
<tr>
<td>Virginia and Maryland</td>
<td>Do not apply manure in winter months.</td>
<td>27</td>
<td>35</td>
</tr>
</tbody>
</table>

† Compliance or adoption rates that were 60% or higher were considered “good”; rates below 60% were considered “poor” and are in bold type.
‡ Statistical significance between states was measured at the 90% confidence level throughout the case study.
the interview about adherence with their plan, resulting in a 65% response rate (Table 5).

Nonadherence comments outnumbered adherence comments 1.6 to 1, although the difference was not statistically significant (Table 5). In addition, the comments broken down by state were not statistically significant, although most Delaware farmers offered comments indicating adherence, whereas most Maryland and Virginia farmers gave comments indicating nonadherence (Table 6). Thus, this was the second dataset that suggests farmer adherence levels with nutrient management plans were more similar than they were different.

Three examples of the comments that indicated farmers were adhering to their plans were (i) “We make more money following the plan by saving on buying N and potash. We’ve cut the rate down 22%.” (ii) “Having a plan has allowed me not to put on N in the fall like they do in the Midwest.” (iii) “I kinda like the nutrient management plan. It gives you a reason to get things done like soil tests.”

Three examples of farmer comments indicating nonadherence with their plans were (i) “Extension recs aren’t worth the paper they’re on. We rely on our fertilizer company and lab results for our true recommendations.” (ii) “Once you get below 3 t ac⁻¹ (poultry manure application rate), there’ll be flow problems. The 1.5 t ac⁻¹ rate in my plan is ridiculous.” (iii) “If we’re cleaning out in winter and there’s nowhere to store it, we’ll spread it to get rid of it.”

Several interviewed farmers, private planners, and fertilizer dealers stated they were actively evading the spirit and letter of the law because they (i) kept double books (one plan to show an inspector and one plan to use to farm), (ii) applied higher manure rates than they knew they should be using, (iii) set higher-than-average yield goals to justify higher nutrient application rates, and (iv) did not take residual N credits.

Several reasons were repeated by multiple farmers for why they did not follow their nutrient management plan, including (i) they think they’ll “go out of business” if they follow their plan, (ii) they do not want to set average yield goals but want ever-increasing yields, and (iii) they do not want to apply manure at low P application rates because they would have to buy commercial N fertilizer. These interviewed farmers perceive the nutrient management plans prepared by university and state agronomists as going too far toward minimizing nutrient losses at the risk of reducing yields below what they consider to be an economically viable optimization for their farming operation.

University and extension service recommendations are becoming less commonly followed in other regions as well. Recent surveys of farmers in Iowa and Michigan suggest that most farmers use fertilizer dealers and crop consultants for their N application rates and rarely seek out agronomic advice from extension or conservation district professionals (Arbuckle and Rosman, 2014; Stuart, 2014). One reason for this was given by one of the private crop consultants interviewed in the present study, who said that he and his farmer clients “are in business together, where the success of one, is the mission of the other.”

Regarding what metric of success is important to farmers, a key informant in a North Carolina study said that “Farmers want to brag about yields and not return on investments” (Osmond et al., 2012), indicating that excessive attention to crop yield could come at the cost of profitability. A Maryland farmer in the present study explained the problem he has with setting an average yield goal as the basis of a state-certified nutrient management plan: “If I can’t fertilize for above my average yield, it’s not fair; so you’re never going to exceed the yield. The only way to make it is on big yields. There’s going to be a day when we go out of business.” Osmond et al. (2012) reports that “farmers (in Nebraska and Kansas) often expressed the need to ensure sufficient nutrients to their crops for optimum yielding years as a guide for determining N rates.”

### Table 5. Categories of comments indicating adherence or nonadherence with nutrient management plans.†

<table>
<thead>
<tr>
<th>Comment categories indicating adherence</th>
<th>Counts</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Farmers explicitly say they are “following the plan.”</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>2. Farmer imply they are “using the plan.”</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>3. Farmers explicitly say they are “following soil tests.”</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>14</td>
<td>39</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comment categories indicating nonadherence</th>
<th>Counts</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Farmers explicitly say they are “not using the plan” or “not following the plan” or they are “breaking the law.”</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>2. Farmers imply they are “not using” or “not following the plan.”</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>3. Farmers explicitly say they are applying nutrients at higher rates than recommended in their plan.</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>4. Farmers explicitly say they are writing false higher yield goals when developing their plan to justify higher nutrient application rates.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>22</td>
<td>61</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

† Comments indicating adherence versus nonadherence were not statistically significant at the 90% confidence level.

### Table 6. Differences in comments across states indicating adherence or nonadherence with nutrient management plans (p = 0.176).

<table>
<thead>
<tr>
<th>Number of farmers by state</th>
<th>Comments indicating adherence</th>
<th>Comments indicating nonadherence</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Maryland (n = 30)</td>
<td>17</td>
<td>47</td>
<td>37</td>
</tr>
<tr>
<td>Delaware (n = 20)</td>
<td>40</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Virginia (n = 5)</td>
<td>20</td>
<td>60</td>
<td>20</td>
</tr>
</tbody>
</table>

Research Question 2: Have the Laws Improved Nutrient Management Practices on the Delmarva Peninsula?

Three datasets presented in this article shed light on whether farmers have improved their nutrient management practices because of the laws: (i) state evaluations of the law, (ii) farmer comments about practices, and (iii) Likert statements reflecting
farmer understanding of nutrient science and agricultural–environmental linkages. Initially, water quality datasets were considered for evaluation during this study, but interviews with water quality experts and agronomists indicated that this would not be a useful exercise because of the considerable natural lag time between land use change and detection of water quality improvements and concern that the amount of land use and behavior change called for in the laws would be insufficient to be detected in the limited number of water monitoring stations.

State Evaluation of the Law

Delaware was the only state to evaluate whether farmers had improved their nutrient management behaviors and whether the law had achieved environmental outcomes. The University of Delaware used two approaches to estimate the effects of the law on the state’s nutrient surplus problem (Sims et al., 2008). They estimated that N surpluses in Delaware were reduced by 55 or 60% and P surpluses shrunk by 52 or 92%, depending on methodology. The authors attributed the success specifically to reduced fertilizer purchases by farmers, the use of phytase in chicken feed by the poultry integrator companies, the state manure transport program, and alternative manure uses (e.g., Perdue’s litter pelletizing plant and transport of manure to the mushroom industry in Pennsylvania). The Delaware Nutrient Management Commission also estimated that the law helped shrink the state’s excess poultry manure problem from over 100,000 tons to less than 10,000 tons per year (Delaware Nutrient Management Commission, 2009).

Interview Comments about Practice Changes

Farmers were asked, “Did you change your fertilizer or manure use because of the law?” Although only 34 of the 55 regulated farmers (62%) provided answers (due to the social desirability problem of this question), most said “yes,” indicating that at least 40% of farmers from Maryland, 45% from Delaware, and 80% from Virginia have improved their nutrient management behaviors (differences between states were not statistically significant). The nutrient management behaviors that farmers say improved because of the law include (i) increased frequency of soil testing, (ii) increased frequency of manure testing, (iii) reduced purchases of commercial P, (iv) lowered N concentrations in the fertilizer mix, (v) lowered poultry manure application rates, and (vi) less disposal of manure by poultry growers. The most commonly repeated phrase by interviewed farmers across all three states in response to this research question was “I have a greater awareness of nutrient management.”

Likert Opinion Statements Reflecting the Understanding about Farm Nutrient Science and Agricultural–Environmental Linkages

Educational outreach efforts that accompanied implementation of the laws were intended to help farmers understand nutrient issues better, including the need for reduced agricultural losses of nutrients. Thus, this study also attempted to determine if farmers had come to accept the scientific information justifying the need for better nutrient management. Many studies from the literature indicate that one important predictor of adoption of best management practices is an awareness of the problem (Ribaudo and Horan, 1999; Prokopy et al., 2008; Stuart et al., 2014). Overall, the answer is “no”; that is, none of the laws achieved a widespread understanding by the interviewed farmers of farm nutrient science or of the agricultural–environmental linkages (Table 7).

For example, only half of all farmers (47–55%) agreed with the Likert statement, drawn from conclusions in the scientific literature, that “Pre-phytase manure application on corn on a nitrogen basis can result in up to three to four times as much phosphorus application as necessary for corn.” Perhaps most disappointing was that between 60 and 85% of the interviewed farmers said they disagreed or did not know that “Even without soil erosion, it is possible for dissolved phosphorus to runoff from soils with Very High Phosphorus soil test values.” The statement reflects the new, updated science that the scientific community was trying to disseminate in 1997.

Regarding the potential to achieve universal acceptance of important watershedscale agricultural–environmental linkages, a large majority of farmers (80–100%) disagreed with the scientific consensus that “Agricultural sources from the entire Chesapeake Bay watershed make up a majority of the nitrogen and phosphorus entering the Bay” (Table 7). Only a little over half (50–67%) could agree that “In certain counties on the Delmarva Peninsula, there is more poultry manure produced than can be applied at agronomic rates in the same county.” About half to 70% could agree that “In the past, it was customary for many poultry growers in my state to apply poultry manure on nearby fields for disposal purposes.” Despite this lack of widespread agreement on these agricultural–environmental linkages, nearly all farmers (95–100%) agreed that “Protecting the environment is part of what it means to be a farmer.”

Discussion

Five lessons learned about regulating farmers are discussed, and some policy recommendations are provided here.

Plan-Based Agricultural Regulations Are, in Reality, Voluntary

Given the “insidious” nature of nonpoint-source pollution (Stonehouse, 1997), inspectors cannot easily detect and attribute nutrient pollution to a specific farm; nor can they easily determine whether a farmer is following a certified nutrient management plan or other management-related practices (Innes, 2000; Purvis and Outlaw, 1995). Farmers who do not believe that following the nutrient recommendations in their plan would produce an economically viable crop or are too risk averse to give it a try are not easily regulated.

Even under the voluntary program approach, Osmond et al. (2015) observed that farmers were disinclined to adopt practices that require a considerable amount of “management,” which is the essence of nutrient management plans. Luloff et al. (2012) found that the least liked voluntary conservation practices were nutrient management and riparian buffers. Exner et al. (2010) determined that the improvement in groundwater nitrate in the regulated Central Platte Valley was due primarily to farmers switching from furrow to sprinkler irrigation, whereas very few N management–related practices changed.

It is apparent that management-related requirements, though critical and maybe the most effective, can be the least easy for farmers to accept, adopt, and maintain. Nutrient management plans as a regulatory mechanism are highly intrusive and require
significant acceptance and behavioral change for them to be successful. If, according to Charlton (1985), farmers regard plans as detrimental to their economic self-interest, perceive the costs of following the plan as greater than the penalties for not following the plan, and see a low probability of getting caught, they will not follow the plan.

**Plans Prepared by Private Sector and Public Sector Planners Result in Nonuniform Standards**

Given the reality that government capacity was insufficient to develop nutrient management plans for all farmers in even these very small regulated farming populations, certifying independent crop consultants and fertilizer dealers to also write plans for farmers was necessary. However, this case study demonstrated that direct reports from several farmers and some planners suggest that some private planners were recommending higher nutrient application rates than public planners, echoing findings from other studies (Smith, 1999; Lawley et al., 2007). Furthermore, this case study found that several private planners and farmers admitted they were actively collaborating to evade the law by preparing “double books,” setting higher-than-average yield goals, using higher manure application rates, and not taking residual N credits. Other farmers revealed in the interviews that they got their “true rates” from their fertilizer dealers even though they had obtained an extension-prepared nutrient management plan.

If the anecdotal results reported here are indicative, a gap in opinion may have existed regarding the amount of nutrients needed to raise a profitable crop while minimizing environmental losses, with farmers, fertilizer dealers, and crop consultants on one side and agronomists from extension and the conservation districts on the other side. Closing this gap, harmonizing recommendations, and building trust are important challenges given recent studies showing that most farmers get their crop fertilization advice from the private sector (Arbuckle and Rosman, 2014; Stuart, 2014).

**Gaining Buy-In by Producers May Result in Better Outcomes than “Alienating” the Regulated Party**

Overall, this case study concludes that better outcomes (administrative compliance, adherence compliance, and even environmental outcomes) have a higher probability of occurring if regulatory approaches emphasize gaining buy-in from farmers than if they alienate farmers. However, a “negotiated” regulatory style rather than an “enforced” style (Shover et al., 1986) can go too far in accommodating the regulated party, resulting in a fine line between gaining buy-in and regulatory capture (Bardach and Kagan, 1982).

Delaware gained buy-in from farmers and gained many positive administrative, behavioral, and environmental outcomes, such as convivial policy-development deliberations, early compliance rates, and scientific assessments, which indicated that the excess manure problem in Delaware had shrunk dramatically. Nevertheless, regulatory capture was a concern because the farmer-dominated Commission had only reported acres in compliance rather than numbers of farmers, some 30% of acres did not appear to be managed under a nutrient management plan, and only 38% of the expected annual implementation reports had been submitted. Maryland alienated farmers and suffered many poor administrative and adherence outcomes.

**Table 7. Likert opinion statements about farmer understanding of nutrient science and agricultural–environmental linkages.**

<table>
<thead>
<tr>
<th>Nutrient science</th>
<th>Number of farmers by state</th>
<th>Agree</th>
<th>Don’t know</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-phytase poultry manure application on corn on a N basis can result in up to three to four times as much P application as necessary for corn (p = 0.645).</td>
<td>MD (n = 30)</td>
<td>47</td>
<td>33</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>DE (n = 20)</td>
<td>55</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>VA (n = 10)</td>
<td>50</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Even without soil erosion, it is possible for dissolved P to runoff from soils with very high P soil test values (p = 0.496).</td>
<td>MD (n = 30)</td>
<td>17</td>
<td>30</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>DE (n = 20)</td>
<td>15</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>VA (n = 10)</td>
<td>40</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Agricultural–environmental linkages</th>
<th>Number of farmers by state</th>
<th>Agree</th>
<th>Don’t know</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural sources from the entire Chesapeake Bay watershed make up a majority of the N and P entering the Chesapeake Bay (p = 0.433).</td>
<td>MD (n = 30)</td>
<td>0</td>
<td>13</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>DE (n = 20)</td>
<td>5</td>
<td>15</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>VA (n = 10)</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>In certain counties on the Delmarva Peninsula, there is more poultry manure produced than can be applied at agronomic rates in the same county (p = 0.639).</td>
<td>MD (n = 30)</td>
<td>67</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>DE (n = 19)</td>
<td>58</td>
<td>5</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>VA (n = 10)</td>
<td>50</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>In the past, it was customary practice for many poultry growers in my state to apply poultry manure on nearby fields for disposal purposes (p = 0.112).</td>
<td>MD (n = 30)</td>
<td>67</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>DE (n = 20)</td>
<td>50</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>VA (n = 10)</td>
<td>70</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Protecting the environment is part of what it means to be a farmer (p = 0.500).</td>
<td>MD (n = 30)</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>DE (n = 20)</td>
<td>95</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>VA (n = 10)</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I would like to receive more nutrient management–related educational materials (p = 0.356).</td>
<td>MD (n = 30)</td>
<td>73</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>DE (n = 20)</td>
<td>50</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>VA (n = 10)</td>
<td>60</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

† DE, Delaware; MD, Maryland; VA, Virginia.
Regulations That Account for the Realities of Farming and State Regulatory Capacity Appear to Result in Better Outcomes

The most successful elements of each state law were those that pinpointed the most significant environmental problems and tailored solutions sufficient to the scale and scope of the problem. Maryland recognized the role that the poultry integrators play in the excess poultry manure problem and the soil P saturation problem, thereby requiring the integrators to share in the cost of manure transport and feed phytase to their chickens. Both Maryland and Delaware recognized the importance of financial and technical assistance to help farmers comply with their laws. Both states provided state-funded manure transport programs and cost-share to hire state-certified private planners and to conduct soil test analyses.

Focusing Events That Turn Out to Be Weak Can Undermine Justification for a New Regulatory Approach

The 1997 *Pfiesteria* fish kill focusing events did not sufficiently satisfy Kingdon’s criteria for effective focusing events. Kingdon (1995) suggests that focusing events can serve to “open policy windows” if (i) they serve as reinforcements for something already taking place, (ii) they are combined with a solid quantification of the problem, and (iii) they provide assurances that the crisis event was not an isolated fluke. To environmentalists, *Pfiesteria* did serve as reinforcement for the long-standing eutrophication problem in the Chesapeake Bay, that a main source of the nutrient pollution was excess poultry manure and commercial fertilizer, and that the voluntary program approach to farmer nutrient management was an inadequate solution. The farming community did not share this view and instead regarded *Pfiesteria* as a powerful symbol for the insulting and incorrect perspective that environmentalists, policymakers, and the media had of farmers: that they wasted manure nutrients (which they contend they could not afford to do) and that they did not care about protecting the environment (which they contend is part of what it means to be a farmer).

Second, the government capacity to quantify the problem was not solid but was very nuanced owing to the difficulty the scientific community had to unequivocally link the *Pfiesteria* fish kills to nutrient pollution and specifically to poultry manure. After many years, *Pfiesteria* has not been detected again in the Bay, thus reinforcing concern that it was an isolated fluke. Terlizzi (2006) suggested that another toxic microorganism (*Karlodinium micrum*), which is associated with nutrient pollution but does not harm humans, was to blame for the fish kills. Terlizzi (2006) posited that had the fish kills in 1997 been attributed to *K. micrum* instead of “The Cell from Hell,” the fish kills’ value as a focusing event would have been limited. Terlizzi suggested that Maryland’s law could have been justified by concerns about oxygen depletion in the Bay and the loss of underwater grasses and has described the Water Quality Improvement Act as “the right law for the wrong reasons.”

Policy Recommendations

For the three states in this case study, the recommendations are (i) to explore why some farmers are reluctant to follow state-certified nutrient management recommendations, including their lack of trust in the recommendations regarding predicted crop yield and economic return, and to develop educational materials to effectively address these issues; (ii) to explore why some farmers do not accept the latest science on the links between agricultural nutrient management and the environment and then tailor outreach materials that capitalize on the sense of “farm stewardship” to counter misperceptions; (iii) to consider trying a formal and traditional enforcement approach by making the cost of noncompliance more expensive than the cost of compliance, consistent with the findings of Brehm and Hamilton (1996) that, when choosing to comply, firms trade off the marginal cost of compliance with the marginal benefit of compliance; and (iv) to explore the costs of compliance to the farmer and noncompliance to society and how these costs can be more effectively shared for the common interests in environmental stewardship, food security, and economic prosperity.

Should the three states in this case study be interested in modifying existing regulatory policies or if other states in the country are interested in pursuing new regulatory policy, the recommendations are that (i) farmers be given an equal seat at the policy-making table during the problem diagnosis stage, are empowered to review and evaluate the evidence of a problem, and are encouraged to weigh, alongside other members of the policy-making community, the pros and cons of various regulatory, voluntary, or market-based policy responses; (ii) states develop regulatory requirements that address significant environmental problems with specific, meaningful, and effective solutions (e.g., phytase for the excess P problem in manure and manure transport to move excess manure away from areas where it can no longer be applied at agronomic rates); and (iii) states link the behavior changes they require of farmers to specific water quality goals, establish methods to predict the potential outcomes of the regulations, evaluate the law, and allow for adaptive management to address implementation problems as they come up.

Conclusions

A regulatory approach to nonpoint source agricultural nutrient pollution will turn out to be voluntary if the state is unable to compel, verify, or enforce compliance. Thus, successful regulations of nonpoint-source pollution likely have to be developed cooperatively with the agricultural industry. Even more importantly, farmers have to be convinced that it is in their economic self-interest to comply with the regulations either because (i) the environmentally protective practices can save them money, (ii) financial assistance programs provide sufficient incentive to comply, or (iii) the cost of noncompliance exceeds the cost of compliance.

States that pursue a regulatory approach can help ensure greater administrative, behavioral, and environmental outcomes by (i) being mindful of the tone and overall regulatory style they embody so that the policy-making process is respectful and inclusive, (ii) choosing regulatory requirements that are straightforward to implement and easy to verify in addition to or in lieu of difficult-to-detect management practices, (iii) effectively designing educational campaigns to convince farmers of the economic and environmental benefits of the required practices, and (iv) considering prioritizing the increasingly limited public financial assistance funds for practices that only
have environmental benefits. Given the enormous effort involved in regulatory policy-making, governments would be wise to establish regulatory policies that have quantifiable administrative and behavioral goals that are directly linked to specified, desired environmental outcomes.

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