Struggles, Success, and Chickens:

Nutrient Management in the Delaware Poultry

Industry and How We Got Here

by

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A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Degree in Environmental Studies with Distinction

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ABSTRACT

The process of regulating Delaware's tremendous poultry industry has been tumultuous since the industry first became the focus of nutrient management regulation. This research seeks to use first-hand testimonies to understand the development of nutrient management over time, how nutrient management is carried out today, and what strategies have been successful in encouraging implementation of practices. The evolution of nutrient management, which started out plagued by ill-feelings between farmers and regulators, has progressed largely due to three main factors utilized to connect stakeholders: strong science and education, collaborative processes and open communication, and non-regulatory middlemen that bridge the gap between farmers and regulators.

EXECUTIVE SUMMARY

The poultry industry in Delaware makes up 74% of the state's vast agricultural industry, which directly and indirectly contributes about $8 billion annually to the state economy.[1] Poultry litter and manure are high in nitrogen and phosphorous, nutrients that make suitable fertilizers but that, in large quantities, may cause detrimental algal growth in aquatic ecosystems.[2] Decades of intensive agricultural activity in Delaware have contributed to the significant presence of these nutrients in the state's waterways, notably in tributaries and sections of the Chesapeake Bay, one of the nation's largest and most biodiverse ecosystems.[3] Declining water quality and the appearance of oxygen-depleted zones has led to intense focus on nutrient management in Delaware over the past 30 years especially, with particular focus on the agricultural industry.

The evolution of nutrient management, which started out plagued by ill-feelings between farmers and regulatory agencies, has progressed largely due to three main factors utilized to connect stakeholders: strong science and education, collaborative processes and open communication, and non-regulatory middlemen, like conservation districts, that bridge the gap between farmers and regulators. These three factors have alleviated some of the reluctance associated with implementing cost-intensive and time-consuming nutrient management practices, and have encouraged

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[1] Kee, E. & Cadwallader, C.

[2] Chesapeake Bay Foundation, 2014

[3] National Oceanic and Atmospheric Administration, 2014

the implementation of best management practices, Comprehensive Nutrient Management Plans, and Nutrient Management Certification.

The advent of the Delaware Nutrient Management Law in 1999, and later, the Environmental Protection Agency's implementation of a Total Maximum Daily Load in 2010, each launched streams of regulation that brought nutrient management even further to the forefront of Delaware's environmental focus. Given the intense concentration on nutrient management in Delaware, the glut of information on the topic can be overwhelming; university researchers, state agencies, federal agencies, independent research organizations, environmental groups and other private and nonprofit parties all weigh in on the issue. The first goal of this research was to develop a comprehensive overview of the chronology of nutrient management development in Delaware, and to understand the specific, technical workings of the poultry industry and how it is regulated. This research aimed to produce a step-by-step report on why nutrient management is important, what specific practices are used, and what the challenges and successes have been in achieving more widespread implementation.

The second goal of this research was to gather firsthand testimony from farmers, agents of regulatory agencies, agents of non-regulatory agencies and organizations, and others with significant experience and expertise in agriculture, nutrient management, and the relationship between the two, to compile information about the changes in nutrient management over the past 30 years. Ten participants were interviewed at length, with particular focus on their perceptions of nutrient management in Delaware and the relationships between stakeholders involved in the conflict. This research was particularly interested in understanding the strategies that

have been successful in promoting the development of nutrient management and the implementation of respective practices. It also investigated past and remaining challenges.

The overarching purpose of this research was to look at nutrient management on a very human level, thus the primary instrument was an interview process. While this research still took a scientific approach in developing and asking questions, in findings, participants are represented by their words, instead of a best-fit option checked on a survey.

This research is important on a local as well as universal level. On the local level, this research provides a foundation for social science investigation into the development of one of Delaware's most significant environmental conflicts. In order to continue to work towards achieving greater nutrient management in Delaware, to improve the state's still-struggling water quality, and to work towards meeting the goals of the Chesapeake Bay Total Maximum Daily Load, we have to know where we came from, where we're going, and what factors have influenced this path.

On a universal level, this research expresses hope that the strategies observed in this environmental conflict may carry implications for possible mitigation of other conflicts. Many environmental issues can be approached and hopefully mitigated through science and education, collaborative processes and open communication, and incorporation of non-regulatory middlemen.

Ultimately, this research asks four questions about nutrient management and agriculture in Delaware: who is involved, how did they become involved, how do they work together, and how can we make that collaboration better?

Chapter 1

BACKGROUND

1.1 The Agricultural Industry in Delaware

The agricultural industry in Delaware is comprised of 2,500 farm operations, including crop and livestock operations.[4] Total market value of agricultural products produced in Delaware in 2014 was over $1.2 billion.[5] Including this total, the United States Department of Agriculture estimates that the agricultural industry in Delaware directly and indirectly contributes nearly $8 billion annually to the state economy.[6] Poultry farming comprises 74% of Delaware's vast agricultural industry.[7]

Sussex County, Delaware, is the national birthplace of the broiler industry, where young chickens are raised for meat.[8] Sussex County ranks first out of the nation's counties in broiler production, with an annual production of over 200 million broilers.[9]

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[4] Kee, E. & Cadwallader, C.

[5] National Agricultural Statistics Service, 2014

[6] Kee, E. & Cadwallader, C.

[7] Kee, E. & Cadwallader, C.

[8] Delmarva Poultry Industry, 2015.

[9] Kee, E. & Cadwallader, C.

1.2 The Poultry Process

Approximately 11 million chickens are produced per week on the Delaware-Maryland-Virginia (Delmarva) Peninsula for four chicken companies, or integrators.[10] Farmers erect and own hen houses for which integrators provide chicks, feed, bedding, and fuel for heat.[11] Hens are fed a mixed corn and soybean meal and kept in the houses for about a seven-week growth cycle.[12] After this period or when the hens reach a "marketable weight" (2-8 pounds depending on species), catching crews from the integrator load the hens into crates and transport them to processing plants.[13]

1.3 The Poultry Industry and the Chesapeake Bay

The Delamarva Peninsula is home to some of the most intensive poultry production in the country. The three peninsula states are also part of the Chesapeake Bay watershed, meaning that runoff, and all the pollutants it transports, from these states drains into the Chesapeake Bay.

Nutrients from manure can be transferred into the environment in several ways:

1. **Manure spillage during clean out**. Poultry farmers generally crust out, or clear the top level of bedding and manure, out of hen houses between each flock.[14] In addition, farmers will occasionally do a full clean-out of a hen

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[10] Delmarva Poultry Industry, 2014

[11] Delmarva Poultry Industry, 2014

[12] Delmarva Poultry Industry, 2014

[13] Delmarva Poultry Industry, 2014

[14] Personal Interview

house, completely removing and replacing bedding. This can occur as frequently as every other year, or farmers may go as long as seven or more years without a full clean out, depending on the requirements of their integrator.[15] Manure spillage can occur during crust out and clean out processes, due to the large amount of manure being moved from houses to storage.[16]

2. **Improper manure storage**. After crusting out, manure is stored until it can be utilized on crop operations, sold, or otherwise moved. Uncovered or improperly stored manure can lead to nutrient runoff with water and wind, or soil infiltration from leeching.[17]
3. **Over application of nutrients**. Crops can only take up a certain quantity of nutrients at any given point in their growth cycles. When manure is applied in excess of crop nutrient needs or at timing incompatible with crop growth and nutrient uptake, remaining nutrients are transported into the surrounding environment, where they can volatize, become sediment bound, and/or be removed by erosion and elements.[18] These processes lead to excess quantities of nutrients in surrounding environments.

The nitrogen and phosphorous present in the poultry manure are necessary for plant growth, but when these nutrients enter an aquatic environment like the

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[15] Personal Interview

[16] Shober, A. L., Riggi, S. & Rothweiler, R., 2015

[17] Volk, J., 2015

[18] Volk, J., 2015

Chesapeake Bay in excessive quantities, they can encourage extreme algal growth.[19] The algae block sunlight from reaching other photosynthetic organisms beneath the surface, and can deplete oxygen levels in the environment.[20] These low-oxygen or oxygen-depleted zones can turn into dead zones as fish and plants are stressed beyond their capacity and die in the unsuitable environment.[21]

Nutrient management (in this research, in reference to nitrogen and phosphorous) and the prevention of nutrient runoff are so vital in part because of Delaware's proximity to the Chesapeake Bay and the risks posed to this rich ecosystem from nutrient runoff.

1.4 Protecting the Chesapeake Bay

According to the National Oceanic and Atmospheric Administration (NOAA), the Chesapeake Bay is the largest estuary in America, and is one of the most fertile bodies of water in the world.[22] The Chesapeake Bay watershed covers 64,000 square miles and includes Delaware, Maryland, Virginia, New York, Pennsylvania, West Virginia, and the District of Columbia.[23] The estuary is home to tremendous

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[19] Chesapeake Bay Foundation, 2014

[20] Chesapeake Bay Foundation, 2014

[21] Chesapeake Bay Foundation, 2014

[22] National Oceanic and Atmospheric Administration, 2014

[23] National Oceanic and Atmospheric Administration, 2014

biodiversity, providing essential habitats for over 250 species of fish and over 300 species of migratory birds, as well as mammals and myriad plant species.[24]

Nutrient management is essential to protecting this environment. There are two main motivations behind the preservation of the Chesapeake Bay and thus the development of nutrient management: preservation of economic value and preservation of intrinsic value.

The Delaware portion of the Chesapeake Bay watershed contributes significantly to the state economy in terms of employment, economic activity, and natural goods and ecosystem services.[25]

According to a Kauffman et. al (2011) of Water Resources Agency at the University of Delaware, annual economic activity in the Delaware portion of the Chesapeake Bay watershed exceeds $2 billion "from benefits associated with water quality, water supply, ecotourism, recreation, agriculture, forest, open space, and navigation".[26] Significant contributors to economic activity in this region, as concluded by Kauffman et. al (2011) are outlined in Table 1.

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[24] National Ocean and Atmospheric Administration, 2014

[25] Kauffman, G. et. al, 2011

[26] Kauffman, G. et. al, 2011

Table 1: Annual Economic Activity Generated from Benefits Provided by the Delaware Portion of the Chesapeake Bay Watershed[27]

Benefit	Annual Economic Value ($ 2010)
Water-quality recreation	$101,629,897
Increased property value due to improved water quality	$392,735,030
Hunting/fishing/bird and wildlife watching	$108,900,000
Agriculture	$522,000,000
Forest carbon storage	$854,600,000
Public park health benefits	$188,537,846

Included in Table 1 are the activities that comprise 5% or greater (over $100 million) of the total economic activity of the area. As the table demonstrates, economic benefit in the Chesapeake Bay area stems significantly from activities that can all be damaged by environmental degradation. Water, air, and land pollution can jeopardize animal species that contribute to recreational industries like hunting and bird watching. In addition, Kauffman et. al (2011) cite almost $400 million annual economic benefit arising from increased property value due to increased water quality (Table 1). As these figures indicate, environmental protection in the Chesapeake Bay watershed is economically essential in Delaware.

In addition, jobs directly and indirectly associated with the Chesapeake Bay watershed, including but not limited to farming, recreation, fishing, and tourism,

[27] Kauffman, G. et. al, 2011

contribute 12,800 total jobs and yield $310 million in wages annually.[28] Of that contribution, about a quarter of jobs directly/indirectly related to the Chesapeake Bay watershed come from ecotourism,[29] an industry which is heavily contingent on environmental health.

The Chesapeake Bay and its surrounding watershed also contribute significant economic value in Delaware in the form of natural goods and ecosystem services. Kauffman et. al (2011) define natural goods as "commodities that can be sold, such as water supply, farm crops, fish, timber, and minerals." Ecosystem services refer to benefits provided to society by natural processes that occur within an ecosystem; examples include flood control and fishery habitat that result from natural wetlands, water filtration and air purification that result from plant processes, and more.[30] Ecosystems in the Chesapeake Bay watershed provide an estimated $3.4 billion worth of natural goods and ecosystem services.[31]

The values described above refer to use value derived from the Chesapeake Bay and its surrounding watershed area in Delaware. The Chesapeake Bay and watershed are also protected for the intrinsic, nonuse value of its components. Intrinsic value refers to the idea that something is inherently valuable because it exists, regardless of the use value it does or does not provide. Nonuse value can be held by

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[28] Kauffman, G. et. al, 2011

[29] Kauffman, G. et. al, 2011

[30] Kauffman, G. et. al, 2011

[31] Kauffman, G. et. al, 2011

people who directly interact with the Bay, as well as by those who have no interaction with the Bay but care about its wellbeing.

1.5 Focusing on Poultry

The agricultural sector is the largest contributor of nitrogen pollution in the Chesapeake Bay, according to the Chesapeake Bay Foundation (2012).[32] According to the Foundation, as of 2012, 38% of nitrogen pollution in the Chesapeake Bay is attributed to agriculture, followed at a distance by sewage and industry (19%), stormwater (16%), air (21%), and septic (4%).[33] 17% of the total nitrogen pollution in the Chesapeake Bay is attributed to manure production and consumption.[34]

While grain and other livestock operations in Delaware contribute to nutrient release, this research chooses to focus on poultry farming for several reasons.

From a biological standpoint, nutrients in poultry manure present particular challenges. Poultry has, on average, two to four times greater concentration of phosphorous than manure from other livestock, including swine and cows.[35] Poultry manure is both nitrogen and phosphorous rich, which makes it a suitable fertilizer for crop operations. However, poultry manure as a source of nitrogen and poultry manure as a source of phosphorous are not synonymous. The nitrogen to phosphorous ratio in poultry (3:1) is much narrower than many crops require (8:1). This means that the

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[32] Chesapeake Bay Foundation, 2014

[33] Chesapeake Bay Foundation, 2014

[34] Chesapeake Bay Foundation, 2014

[35] Sharpley, A. N., Herron, S., & Daniel, T., 2007

amount of manure necessary to fulfill crop nitrogen needs contains far more phosphorous than crops can take up, increasing potential for phosphorous runoff and long-term soil permeation.[36] Poultry manure cannot be spread arbitrarily, then, and takes special monitoring when used as a fertilizer. In addition, the volatility of nitrogen and the ability of both nutrients to move throughout the environment makes poultry manure particularly susceptible to runoff.

It should be noted that this research primarily deals with nutrient management in the processes of generating and storing poultry manure, and not of applying it. Significant progress in nutrient management in Delaware focuses on the application of nutrients to crop operations. These strategies include split manure application, crop targeting, cover crop programs, and others. Because my particular interest was in poultry, and because the inclusion and evaluation of application strategies would have greatly broadened the scope of this research, investigation centered on generation management with some reference to nutrient application management.

Another technical reason to focus on poultry manure is that there is just so much of it in Delaware, with hen houses that hold over a hundred thousand chickens each, and state production over 200 million broilers a year.

It also makes sense to focus on the poultry industry in Delaware from a social and political and policy standpoint. As indicated earlier, the poultry industry makes up 74% of the agricultural industry in Delaware,[37] making the industry politically, economically, and socially significant. Regulations that affect farmers affect industry,

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[36] Sharpley, A. N., Herron, S., & Daniel, T., 2007

[37] Kee, E. & Cadwallader, C.

which in turn affects the state economy. Regulations also can be expected to affect the profits of farmers and integrators. An industry this big can be expected to exert considerable resistance against regulations perceived as too financially and operationally burdensome. We can learn a lot about designing successful regulatory programs by gauging the extent of and factors underlying the success of Delaware's nutrient management strategy.

1.6 Environmental Conflict and Stakeholder Involvement

Duke (2004) explains that environmental conflicts such as this can be viewed as land-use conflicts where a high-intensity user and a low-intensity user seek competing and ultimately incompatible uses of a resource. In the situation of nutrient management in Delaware, the resource at stake is the use of Delaware land and water resources—especially the Chesapeake Bay, tributaries, and watershed. High-intensity users, in this situation, farmers and the agricultural industry, seek to use these resources for intensive agricultural practices involving nutrient application in the industrial process described above. Low-intensity users include individuals who rely on these resources for recreation and ecosystem services like those described above, or who would desire to restrict high-intensity use in order to protect the resource's intrinsic value. This is the ultimate struggle that nutrient management is trying to reconcile: farmers need to use environmental resources for industrial use, but this use compromises the ability of others to gain ecosystem services or intrinsic value from the same resources. This research addresses how farmers and regulators have met this conflict.

It is important to note that the regulatory agencies investigated in this research—namely the United States Environmental Protection Agency, the Delaware

Department of Natural Resources and Environmental Control, and the Delaware Department of Agriculture—are not low-intensity users, but rather the vehicles through which low-intensity use is protected.[38] By understanding how this conflict has evolved and where it is now, we can observe what strategies have been successful in protecting ecosystem services and intrinsic value without completely diminishing the ability of farmers to gain from the use of Delaware's land and water resources.

1.7 Methods

Research methods for this project synthesized secondary and primary research to gain a comprehensive understanding of the development of nutrient management in Delaware, and the factors that promote a collaborative relationship between farmers and regulators regarding nutrient management. Secondary research involved scholarly research and consultation of current resources from organizations including state agencies, federal agencies, non-governmental and non-profit organizations, and research institutions.

The primary research component of this project involved conducting interviews with individuals involved with or experienced in nutrient management in Delaware. In order to truly understand nutrient management in Delaware, I wanted to get on the ground and gather firsthand testimony from the people directly involved. This took the form of personal interviews, generally 45-60 minutes in length, in which participants were asked a variety of questions about their experience with nutrient management in agriculture, and their perspectives on its implementation in Delaware and particular function in regards to agriculture.

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[38] Duke, J.M., 2004

Farmers were asked about their nutrient management practices, both mandatory and voluntary. They were also asked about changes in the farming industry over time, and changes in the relationships between the farming community and regulatory agencies, among other questions.

Regulators and third-party participants (members of non-regulatory or non-governmental bodies, researchers) were asked similar questions, but inquiries were more geared towards their particular agency's or organization's role in nutrient management, and the agency or organization's relationship with the farming community.

All participants were asked to share their perceptions of the relationships between farmers and regulatory agencies, and their perceptions of the level of attention given to nutrient management in Delaware. For transcripts of interview questions, see Appendices A-C.

Primary research also included attendance at two conservation district meetings, Kent Conservation District and Sussex Conservation District, as well as a visit to a 130,000 broiler operation in southern Delaware. Here, I was able to observe hen houses in operation. The farmers took me inside the hen houses, where I was able to view the food and water dispensers, set up, heating/cooling mechanisms, and of course, chickens. In addition, they showed me their implemented best management practices, including heavy use pads, mortality composting, and manure storage sheds.

Interviews were gathered from ten participants with extensive experience with nutrient management and agriculture in Delaware. Many participants had over two decades of experience in one or both fields. Several participants held multiple positions relevant to the field (for instance, a farmer who was also a member of the

Nutrient Management Commission). To protect the identities of the participants, participants are referred to by pseudonyms, and are only ever referred to by one role at a time when they are referenced by this research.

Collectively, the participants of this research constitute:

- Farmer -- Mixed 119,000 bird; 1,000 acres crop
- Farmer -- Mixed 130,000 bird; 2,000 acres crop
- Farmer -- 3,000 acre crop
- Farmer -- 156,000 bird
- 2 University of Delaware Researchers
- University of Delaware Cooperative Extension Agent
- Delaware Department of Agriculture Agent
- Delaware Department of Natural Resources and Environmental Control Agent
- 2 Members of Delaware Nutrient Management Commission
- 2 Sussex Conservation District Agents
- Kent Conservation District Board Member
- Delaware Farm Bureau Board Member

The interview process followed Institutional Review Board (IRB) protocol; interview scripts and consent forms were approved through the University of Delaware IRB panel. Research participants all read, agreed to, and signed a consent form informing them of the project's purpose and the terms of participation before they were interviewed. Each interview was audio-recorded for accuracy. In each

participant's testimony, I looked for patterns and common themes, relating firsthand accounts to secondary literature to understand the inner workings of the poultry industry, nutrient management regulation, and the ways both have developed.

Chapter 2

OUTLINE OF EVENTS

The following sections describe how nutrient management in Delaware developed over time, and how participating parties became involved in the conflict of nutrient management and resource protection. This section is intended to provide an understanding of the players in nutrient management and their roles within the conflict.

Nutrient management is a multi-layered, multi-disciplinary and multi-organizational effort in Delaware. There is not one organization or law that completely governs nutrient management; it occurs at the national, state, county, municipal, and individual level. This section is intended to help the reader understand how these different levels developed chronologically, how entities within each level function, and provides a statement about the way each event outlined is relevant to nutrient management in Delaware and this research in specific.

The goal of this research was to understand and identify those factors which facilitate relationships between stakeholders in this conflict. In order to understand these relationships, it is important to understand who these stakeholders are, how they developed, and what their purposes are.

In addition, this section demonstrates that, while focus on nutrient management really came to the forefront of Delaware policy beginning in the 1980s, conservation practices influencing soil and water quality have been a long-standing and developing focus over the past century.

2.1 1914: University of Delaware Cooperative Extension is established.

Overview

University of Delaware Cooperative Extension is established to provide educational and scientific resources to the Delaware community.

Event:

University of Delaware Cooperative Extension was established in 1914 with funding from the national Smith Lever Act.[39] Cooperative Extension is housed in the University of Delaware and connects Delaware's public citizens to university resources, research, and information.[40] Cooperative Extension aims to provide "unbiased, research-based resources" to farmers through educational classes, workshops, programs, events, and outreach personnel.[41]

Cooperative Extension also provides certification classes for farmers and workers in other industries, like lawn care, who are required by law to be certified in nutrient management.[42]

Cooperative Extension is currently involved in nutrient management in Delaware acting as a valuable middleman between regulators and farmers.

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[39] University of Delaware Cooperative Extension

[40] University of Delaware Cooperative Extension

[41] University of Delaware Cooperative Extension

[42] University of Delaware Cooperative Extension

Cooperative Extension helps farmers reach compliance and nutrient management standards.

2.2 1937: National legislation leads to the creation of conservation districts.

Overview

The development of conservation districts throughout the country creates non-regulatory public agencies to help farmers bring their operations into compliance and keep up with best management practices.

Event

The creation of conservation districts was initiated in the 1930s when poor management of soil and water resources along with an extended drought led to an ecological disaster known as the Dust Bowl.[43] Huge quantities of eroded soil and dust blew across the American Midwest, displacing thousands of people overcome by the dust storms.[44] In response, congress declared soil and water conservation a national policy priority, and President Franklin D. Roosevelt encouraged state governments to form legislation enabling the creation of conservation districts.[45] According to the National Association of Conservation Districts, "Congress realized that only active,

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[43] National Association of Conservation Districts, 2012

[44] National Association of Conservation Districts, 2012

[45] National Association of Conservation Districts, 2012

voluntary support from landowners would guarantee the success of conservation work on private land."[46]

Today, there are almost 3,000 conservation districts in states and counties across America.[47] Delaware has a conservation district in each of its three counties: New Castle County, Kent County, and Sussex County. This research will focus on the impacts of Kent County and Sussex County conservation districts on nutrient management, as these two counties are more agriculture intensive than New Castle County, which is more urban.

2.3 1943: Kent Conversation District is established.

Overview

Kent Conservation District is created, providing support for farmers in implementing nutrient management practices and acting as a non-regulatory middleman between regulators and farmers.

Event

The Kent Conservation District was established in 1943 under Title 7 of Delaware Code, Chapter 39.[48] The district is managed by a board comprised of elected local landowners and representatives from the Delaware Department of

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[46] National Association of Conservation Districts, 2012

[47] National Association of Conservation Districts, 2012

[48] Kent Conservation District, 2014

Natural Resources and Environmental Control (DNREC), the Kent County government, and University of Delaware Cooperative Extension.[49] The conservation district's main purpose is to bring attention to land and water related resource issues and work on collaborative solutions to these problems, while encouraging education about the connections between human activities and the natural environment.[50]

In continuation of the conservation districts' original purpose, Kent Conservation District works with farmers to address erosion and sediment control, while also confronting issues related to water quality protection, sustainable agriculture, land use planning, and other related conservation issues.[51] In addition, the conservation district operates cost-share programs for farmers seeking financial support in implementing best management practices, educational services, and support in nutrient management including writing required Comprehensive Nutrient Management Plans.

2.4 1944: Sussex Conservation District is established.

Overview

Sussex Conservation District is created, providing support for farmers in implementing nutrient management and acting as a non-regulatory middleman between regulators and farmers.

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[49] Kent Conservation District, 2014

[50] Kent Conservation District, 2014

[51] Kent Conservation District, 2014

Event

As with the Kent Conservation District, the Sussex Conservation District was enabled by Delaware's legislature in April 1943.[52] Under the enabling act, the Soil Conservation Commission was created to decide the functions of the districts, designate boundaries, and hold elections for the first boards.[53] Public referendum confirmed the Sussex Conservation District in December 1943, and the district was fully established in February 1944.[54]

As Sussex County is one of the largest poultry producing areas of the country, nutrient management here is of utmost focus and importance. The Sussex Conservation District provides support for farmers to implement nutrient management practices, services including Comprehensive Nutrient Management Plan writing, educational support, and cost-share programs for the implementation of best management practices. In addition, conservation district agents may serve as liaisons between regulatory agencies and farmers.

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[52] Sussex Conservation District, 2014

[53] Sussex Conservation District, 2014

[54] Sussex Conservation District, 2014

2.5 1972: The Clean Water Act is developed.

Overview

The Federal Water Pollution Control Act is significantly amended to become the Clean Water Act, giving the United States Environmental Protection Agency, a federal regulatory agency, significant play in regulating water quality around the country.

Event

The Clean Water Act (CWA) (33 U.S.C. §1251) was first established as the Federal Water Pollution Control Act in 1948, but was revamped and significantly amended to become the Clean Water Act in 1972.[55] The Act was the first federal legislation focused around protecting water quality.[56] The federal statute was designed to protect and maintain the "chemical, physical, and biological integrity" of waters of the United States.[57] The CWA established national structures for regulating pollutant discharge and surface water quality standards for the nation's waterways.[58]

The 1972 CWA Amendments achieved a number of important advancements in national water quality protection by establishing structures for pollution and discharge regulation, maintaining requirements for setting quality standards for

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[55] United States Environmental Protection Agency, 2011

[56] United States Environmental Protection Agency, 2011

[57] 33 U.S.C. §1251 Title 1 §101(a)

[58] United States Environmental Protection Agency, 2011

surface water contaminants, providing funding for construction of sewage treatment plants, and recognizing the contribution of nonpoint sources to water pollution.[59] In addition, the Amendments made it illegal for point sources to release pollutants into "navigable waters" without a permit.[60]

Section 303 subsection (d) of the CWA requires that states identify impaired waters that need enhanced regulation to meet federal water quality standards.[61] For these waters, the EPA may mandate a Total Maximum Daily Load (TMDL), establishing a limit for the amount of particular pollutants that can be released into the body of water without causing it to exceed federal safety standards.[62] The CWA requires that states implement a TMDL "at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality."[63]

The Clean Water Act has been one of the most influential regulatory forces behind nutrient management in Delaware. In 2010, the United States Environmental Protection Agency issued a TMDL under the Clean Water Act for the Chesapeake Bay for nitrogen, phosphorous, and sediment. Because agriculture contributes so strongly to nitrogen and phosphorous runoff, Delaware state agencies were forced to enhance

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[59] United States Environmental Protection Agency, 2011

[60] United States Environmental Protection Agency, 2011

[61] 33 U.S.C. §1251 303 (d)

[62] 33 U.S.C. §1251 303 (d)

[63] 33 U.S.C. §1251 303 (d)(1)(C)

nutrient management regulation and increase focus on bringing farmers on board with best management practices in order to work towards the legally binding standards of the TMDL.

2.6 1997: *Pfiesteria piscicida* outbreak occurs.

Overview

An outbreak of *Pfiesteria piscicida* results in massive fish kills in tributaries of the Chesapeake Bay, strengthening public awareness of water quality and increasing the role that the scientific community plays in nutrient management by illustrating the importance of science in understanding the movement of nutrients through the environment.

Event

In 1997, several Eastern Shore tributaries of the Chesapeake Bay experienced massive fish kills, with thousands of mortalities.[64] Lesions found on the fish implicated *Pfiesteria piscicida*, a dinoflagellate, single-celled organism found naturally in coastal environments.[65] According to the Maryland Department of Natural Resources, *Pfiesteria* is a natural inhabitant of tidal rivers and estuaries, generally exists in non-toxic forms, and feeds on algae and bacteria. However, when large outbreaks of *Pfiesteria* occur, they have been known to attack, impair, and feed on

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[64] Maryland Department of Natural Resources

[65] Maryland Department of Natural Resources

fish.[66] North Carolina has been subject to fish kills in the millions due to *Pfiesteria* outbreaks.[67] These outbreaks have been tied to the presence of excess nutrients in aquatic environments.[68]

In 1997, suspicions of *Pfiesteria* population growth in Chesapeake tributaries, including areas of Maryland, quickly caught media attention.[69] In August 1997, a four-day fish kill involving at least 10,000-15,000 fish occurred in Maryland's lower Pocomoke River; the bloody lesions found on the fish and erratic behavior mimicked symptoms of fish affected by *Pfiesteria* in North Carolina.[70] A second fish kill of similar magnitude occurred later the same month.[71] Watermen in the area also reported adverse health effects, including cognitive impairments, skin irritation, respiratory issues, and complications with other vital organs including the kidneys and liver.[72] It is unclear whether connection of these health effects to *Pfiesteria* was ever confirmed.

Research suggests that significant increases in *Pfiesteria* populations are encouraged by nutrient-loading in waterways, including nitrogen and phosphorous.[73]

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[66] Maryland Department of Natural Resources

[67] Maryland Department of Natural Resources

[68] Maryland Department of Natural Resources

[69] Magnien, R.E., 2001

[70] Magnien, R.E., 2001

[71] Magnien, R.E., 2001

[72] Maryland Department of Natural Resources

[73] Maryland Department of Natural Resources

Nutrients feed and increase algal populations that *Pfiesteria* feed on, and in correlation, *Pfiesteria* populations increase to toxic numbers.[74] Nutrient loading has been linked to *Pfiesteria* outbreaks, meaning that this concerning event carried implications for nutrient regulation, and by association, the agricultural industry.

The *Pfiesteria* outbreak brought national attention to water quality and the presence of nutrients migrating into waterways. According to Bob Nichols of the Delaware Department of Agriculture (DDA), this attention was largely due to the fact that the outbreak influenced a significant source of economic and recreational value. He stated, "The general public was aware of the *Pfiesteria* problem, because it was a problem for the watermen, and any time you affect fish, and the fishing industry, which can be both commercial and pleasure, it affects a broader community."[75] According to Nichols, scientific discovery surrounding investigation of *Pfiesteria* contributed to better nutrient application practices, and understanding of the way nutrients move through the environment.[76]

2.7 1999: The Delaware Nutrient Management Law is passed.

Overview

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[74] Maryland Department of Natural Resources

[75] Personal Interview

[76] Personal Interview

The Delaware Nutrient Management Law is passed as a landmark piece of legislation. It results in an increase in state agency involvement in nutrient management by creating mandatory nutrient management practices through regulation.

Event

The Delaware Nutrient Management Law was passed in 1999 to address growing water quality issues in Delaware.[77] The law built regulation for activities that involve the application of nutrients, like agricultural activities and commercial landscaping, and established programs for nutrient planning and implementation of best management practices in industries handling and applying nutrients.[78] The Delaware Nutrient Management Law aimed to develop and implement these programs to improve water quality without compromising the economic success of the agricultural industry.[79] In order to achieve this and other goals, the Delaware Nutrient Management Law also established the Delaware Nutrient Management Commission.

2.8 1999-2000: The Delaware Nutrient Management Commission is established.

Overview

The Delaware Nutrient Management Law creates the Delaware Nutrient Management Commission (DNMC), a coalition of representatives from state agencies,

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[77] Shober, A.L. & Riggi, S.Y., 2013

[78] Shober, A.L. & Riggi, S.Y., 2013

[79] Shober, A.L. & Riggi, S.Y., 2013

industries involving nutrient application (namely agriculture and landscaping), and relevant fields of expertise. The Commission enables collaborative policymaking regarding nutrient management in Delaware.

Event:

The Delaware Nutrient Management Commission was officially established in 2000. The Commission consists of seven full-time farmers, one DNREC administrator, one nutrient consultant, one representative each from the lawn care and nursery industries, one commercial nutrient applicator, one public citizen, and two representatives from environmental organizations.[80]

The DNMC's duties extend into the development of nutrient management regulations, creation of policy, and development of techniques for helping farmers reach regulatory goals.[81] The Commission's role includes creating educational programs for farmers, encouraging best management practices, developing programs for alternative use and transportation of nutrients, and other tasks.[82]

The Delaware Nutrient Management Commission, under the Delaware Nutrient Management Law, is one of the key channels for successful collaboration on nutrient management in Delaware.

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[80] Shober, A.L. & Riggi, S.Y., 2013

[81] Shober, A.L. & Riggi, S.Y., 2013

[82] Shober, A.L. & Riggi, S.Y., 2013

2.9 2010: The Environmental Protection Agency institutes a Total Maximum Daily Load for the Chesapeake Bay.

Overview

The implementation of a TMDL for the Chesapeake Bay gives the EPA further jurisdiction over water quality in the watershed, including Delaware, and the methods needed to attain them. The duties of state agencies increase as a result, as they are required to create and implement Watershed Implementation Plans and to increase efforts in nutrient management practices.

Event

In December 2010, the United States Environmental Protection Agency established a Total Maximum Daily Load (TMDL) for nitrogen, phosphorous, and sediment deposited in the Chesapeake Bay.[83] The TMDL was established for the entire Chesapeake Bay watershed, covering 64,000 square miles, and was the largest ever implemented by the EPA.[84] The limits set by the TMDL can be seen in Table 2.

[83] United States Environmental Protection Agency, 2013

[84] United States Environmental Protection Agency, 2013

Table 2: Total Maximum Daily Load for Chesapeake Bay

Pollutant	Total Maximum Daily Load Limits (in pounds)[85]	Reduction Requirement (from 2009 baseline)[86]
Nitrogen	185.9 million	25%
Phosphorous	12.5 million	24%
Sediment	6.45 billion	20%

The TMDL is broken into several sections. Each of the six Bay states is required to have a Watershed Implementation Plan that details methods and a timetable for reaching pollution allocations.[87] The Bay TMDL is also broken up into even smaller units; the entire TMDL is comprised of 92 smaller TMDLs for the Chesapeake Bay tidal segments.[88]

According to the EPA, the Bay TMDL is further enhanced by a heightened level of accountability written into the regulation; along with the Watershed Implementation Plans, states are also assessed regarding their two year milestones, and may be subject to federal action if restrictions and improvement standards are not met.[89]

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[85] United States Environmental Protection Agency, 2013

[86] United States Environmental Protection Agency

[87] United States Environmental Protection Agency, 2013

[88] United States Environmental Protection Agency, 2013

[89] United States Environmental Protection Agency, 2013

Chapter 3

MECHANISMS FOR NUTRIENT MANAGEMENT

As a result of the events described above, the agricultural industry was forced to adapt farm operations to mitigate nutrient release. This section will detail the current mitigation efforts in Delaware poultry farming that were most prominently discussed by research participants. These efforts include mandatory practices and voluntary best management practices (BMPs). As stated previously, this research will focus on generator best management practices, with occasional, but not comprehensive, coverage of nutrient management in application.

3.1 Comprehensive Nutrient Management Plans

Under the Delaware Nutrient Management Law of 1999, generators and applicators of nutrients are required to have a Comprehensive Nutrient Management Plan (CNMP).[90] The law applies to individuals with eight or more animal units (shown in Table 3) and/or to individuals who apply nutrients to ten or more acres.[91]

[90] Shober, A.L. & Riggi, S.Y., 2013

[91] Shober, A.L. & Riggi, S.Y., 2013

Table 3: Poultry Equivalents of 8 Animal Units[92]

Bird	Average Weight (lbs per animal)	Animal Unit Equivalent	Number of Animals in 8 Animal Units
Roaster	4	0.004	2000
Broiler	3	0.003	2667
Cornish	1.5	0.0015	5334
Layer	3	0.003	2667

CNMPs include technical operation information, including a map of the operation with wells and tax ditches marked.[93] The plans also include maps of the water flow over the land, and soils maps with the types and productivity of soils.[94] For applicators, the CNMP also includes recommendations for application of nutrients,[95] depending on the type of crop the farmer plans to plant, rotations, current soil status, and other factors.

There are three ways in which an individual can obtain a legally recognized CNMP. A common option is through the county conservation districts; in Delaware, conservation districts will conduct soil sampling, write required CNMPs, and provide nutrient application recommendations for farmers at no cost.[96] If a farmer chooses to not use the conservation district's service, they can opt to hire a private, certified

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[92] Shober, A.L. & Riggi, S.Y., 2013

[93] Personal Interview

[94] Personal Interview

[95] Personal Interview

[96] Personal Interview

nutrient management consultant. Cost-share money may be available to help farmers with the cost of hiring a private consultant.[97] Farmers may choose this option if they want a nutrient management plan that covers more than the basic nitrogen-phosphorous-potassium recommendations provided by the conservation district; for example, some plans include irrigation recommendations.[98]

The third way an individual may obtain a CNMP is to become a certified nutrient consultant through nutrient management certification programs.[99] Certified individuals may then write their own CNMP.[100]

Comprehensive Nutrient Management Plans must be submitted for each qualifying operation every three years.[101]

3.2 Nutrient Management Certification

Under the Delaware Nutrient Management Law, generators and applicators of the same standard as above (8 or more animal units; application to 10 or more acres) are also required to become nutrient management certified through certification sessions and continuing education credits. Certification classes are offered through the

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[97] Personal Interview

[98] Personal Interview

[99] Personal Interview

[100] Personal Interview

[101] Personal Interview

University of Delaware Cooperative Extension, and continuing education credits can be earned through approved educational workshops, classes, and events.[102]

There are four levels of nutrient management certification that an individual may achieve based on their nutrient handling.

1. **Nutrient Generator**: Required level of certification for individual who has an operation with 8 or more animal units, and owns, rents, or manages 10 or fewer acres of land to which nutrients are applied.[103]
2. **Private Nutrient Handler**: Required level of certification for individual who owns, rents, or manages 10 or more acres to which nutrients are applied.[104]
3. **Commercial Nutrient Handler**: Required level of certification for individual who applies nutrients to 10 or more acres of land for commercial business[105].
4. **Nutrient Consultant**: Individuals who achieve this level of nutrient management certification are certified to write nutrient management plans.[106]

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[102] Shober, A.L. & Riggi, S.Y., 2013

[103] Shober, A.L. & Riggi, S.Y., 2013

[104] Shober, A.L. & Riggi, S.Y., 2013

[105] Shober, A.L. & Riggi, S.Y., 2013

[106] Shober, A.L. & Riggi, S.Y., 2013

3.3 Animal Waste Management Plans

Individuals whose operations have 8 or more animal units but who do not apply nutrients to 10 or more acres are required to have an animal waste management plan in addition to a CNMP.[107] Animal waste plans must be done every five years for each operation. In Delaware, conservation districts offer plan developing and writing services at no cost.[108]

3.4 Cost Share Programs

Cost share programs provide federal and/or state funding for farmers to implement best management practices. Cost share money can be allocated through state agencies and the conservation districts, and through the federal Natural Resources Conservation District. Through the state's bond bill, there are over a million dollars allocated for conservation cost-share.[109] Other funding is allocated through the Clean Water Act's nonpoint source pollution program, and the Chesapeake Bay Program.

3.5 Heavy Use Pads

Heavy use pads are concrete foundations placed at entrances to poultry houses and manure sheds. They serve as a catch-all and protective layer on top of soil to prevent spillover when farmers crust or clean out sheds. During these processes, as well as during storage before manure is used for fertilizer, litter can be hard to contain

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[107] Shober, A.L. & Riggi, S.Y., 2013

[108] Personal Interview

[109] Personal Interview

and can drop onto the ground around the sheds, allowing manure to leech nutrients into the soil. It is much easier for farmers to collect and clean litter from the even, impervious pads than to try to scrape it out of grass, dirt, or stone. Cost assistance for installation can be available through cost-share programs through county and national conservation districts.[110]

3.6 Manure Storage Sheds

Manure storage sheds are large structures that cover and contain manure after crust out and clean out, but before application to fields. They are typically comprised of two walls, a roof, and an impervious floor.

Figure 1: Manure Storage Shed[111]

Sheds protect manure from rain and wind, preventing erosion and weathering that can cause nutrients from manure to leech into the surrounding environment and

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[110] Personal Interview

[111] Shober, A. L., Riggi, S. & Rothweiler, R., 2015

get caught in runoff. Manure can be stored for several months between clean and crust out, and removal and use by a farmer. Funding for manure shed construction is also available through county and national cost-share programs. For example, the Sussex Conservation District will supply farmers with 75% of the cost of a manure shed, up to a cap of $30,000.[112]

3.7 Windrow Composting

Litter can spread pathogens from one flock to the next, but completely replacing litter between every flock (so roughly every 7-9 weeks) would be tremendously expensive and produce far more litter and manure than can legally or should reasonably be spread for the operation.[113] An alternative to this is in-house windrow composting, a process by which litter is churned by large machinery and formed into compost piles.[114] During the process, litter generally reaches an average temperature of 140˚ Fahrenheit, which kills pathogens.[115] This process allows farmers to reuse litter without worrying about transferring pathogens from one flock to another, and conserves litter, meaning less nutrient surplus to account for.[116]

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[112] Personal Interview

[113] Macklin, K., Simpson, G., Donald, J., & Campbell, J., 2007

[114] Macklin, K., Simpson, G., Donald, J., & Campbell, J., 2007

[115] Macklin, K., Simpson, G., Donald, J., & Campbell, J., 2007

[116] Macklin, K., Simpson, G., Donald, J., & Campbell, J., 2007

3.8 Others

In addition to the main strategies indicated above, there are other practices that were less discussed by participants, or that don't apply as directly to this research. A major nutrient management program mentioned was the cover crop program, where farmers are encouraged to plant non-harvest crops in their fields during non-growing seasons to trap soil and nutrients. This research chose to focus mainly on nutrient management efforts taken by generators of poultry litter and manure, but it should be noted that significant efforts in nutrient management in Delaware are taken by applicators of manure.

Chapter 4

STAKEHOLDER PERCEPTIONS OF NUTRIENT MANAGEMENT

While stakeholder tension over nutrient management regulation originally gave the impression that there are two, polarized sides of nutrient management regulation—enforcers and enforcees—this research found that there are key players in nutrient management in Delaware that don't fall into either category. These other participants include researchers, conservationists, and public agencies without enforcement power. Non-regulatory groups are integral to maintaining a productive relationship between farmers and regulatory bodies. While I had accounted for other participants in the initial creation of the project, I expected for their interviews to be purely informational, providing background about the industry, science, or agency structure and jurisdiction. Instead, these participants became part of the target population of this study.

Furthermore, this research didn't originally account for overlap between stakeholder positions; by this, I mean that a person with agricultural experience can also be a state agent, or be connected to a third party. Thus, I had trouble categorizing people into "farmers" and "regulators" when there turned out to be overlap and other options.

For these reasons, the research method of this project shifted from gathering and comparing testimonies of farmers and regulators and toward the less specific task of gathering testimony from individuals involved and knowledgeable in nutrient management in Delaware, while still maintaining a focus on the relationship between farmers and regulators. Thus the project took on a more humanistic tone; participants became less fountains of data and instead, truer, multi-faceted human subjects.

4.1 Nutrient Management Then and Now

The motivation behind implementing certain practices on farm operations has changed dramatically since the agricultural industry became the intense focus of nutrient management in the 1980s. According to Bob Nichols of the DDA, prior to nutrient management laws, many farming practices were voluntary best management practices intended to optimize yield and maintain "good neighbor" relationships with surrounding agricultural areas. "I would say it's completely different," said Nichols when asked if nutrient management in the Delaware agricultural industry has changed over the decades that he has been working in the field.[117] "When I handled these problems, there weren't regulations to be enforced," he continued.[118]

Participants indicated that, besides propagating good neighbor relationships with local residents, farm practices were also enacted to improve yield/operations and for time efficiency or convenience. James Wolfe, a conservation district agent, provided an example of how these goals played a role in farm practices before regulation in 1999. He talked about how farmers dealt with chicken mortalities easily and quickly before regulation stepped in: "They've always had to deal with mortality issues," he said.[119] "Prior to composters really coming around, the common practice was you just dug a pit and buried a lot of that."[120]

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[117] Personal Interview

[118] Personal Interview

[119] Personal Interview

[120] Personal Interview

Like the practice of burying mortalities, it wasn't unheard of for farmers, in the past, to spread any and all manure produced just because it was available. Carl Silverstein explained this saying, "Before, when I was growing up, we tended to spread the manure closer to the barn just to get rid of it."[121] Farmers are nothing if not practical; actions on a farm are not arbitrary but chosen to contribute to the efficiency and operation of a farm. This is an important factor to remember in encouraging best management practices.

According to George Brecht, a researcher at the University of Delaware for over 30 years, when studies began correlating agriculture and ground water pollution, the agricultural industry was reluctant to accept and sometimes militant in denying agriculture's contributions.[122] Brecht, who was lead on one of the studies published that implicated agriculture's connection to nutrient pollution, received public backlash from members of the agricultural community, including officials in the Department of Agriculture who grew up around the industry.[123] "I was invited to give talks at local meetings and things like that," Brecht said.[124] About the audience, he said, "They didn't believe what we were saying. They said, 'Oh, you guys don't know what you're

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[121] Personal Interview

[122] Personal Interview

[123] Personal Interview

[124] Personal Interview

talking about.'"[125] He also cited threats to his job from people who felt his findings threatened the agricultural industry.[126]

Roger Carson of DNREC stated simply that between the agricultural community and DNREC, there was "bad blood" over the push for more conservation and nutrient management practices.[127]

Despite the rough beginning, participants indicated that stakeholder relationships are miles from where they used to be, and that nutrient management is much more of a cooperative process now today than it used to be. "Since the [comprehensive nutrient management] program has been in place 14 years, the industry is on board with what the regulations are," said Nichols of the DDA.[128] "They're following those programs, or nutrient management plans, and the plans really identify the soil needs for the nutrients of crops going in."[129]

"I think the farming community's relationship with regulators is probably better now than it has been," said Joanne Hartley, a poultry farmer.[130] Other participants indicated the same, or stronger, sentiments.

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[125] Personal Interview

[126] Personal Interview

[127] Personal Interview

[128] Personal Interview

[129] Personal Interview

[130] Personal Interview

4.2 Driving Forces behind Implementation

As discussed above, an important difference in conservation practice implementation on farm operation was the driving motivation for using such practices. As indicated above, pre-Nutrient Management Law, farmers primarily implemented conservation practices if they improved the farmer's relationship with their neighbors, and if the practice increased yield or reduced cost (monetary and in time). This research found that, today, participants identified three major driving forces that encourage farmers to implement nutrient management practices:

1. Likelihood of economic benefit
2. Fear of facing repercussions for noncompliance
3. Value of land and environmental stewardship.

4.2.1 Likelihood of Economic Benefit

Participants indicated that the most influential factor in encouraging compliance and implementation of BMPs was projected benefit to the farm operation. Best management practices involve investment of some kind; manure sheds and composters can be exceedingly expensive, and practices like cover crops for nutrient uptake on crop operations require time and effort in something that doesn't reap any direct financial benefits. However, these practices benefit farm operations and provide indirect economic benefit, not through direct profit but in saving farmers other costs. Joanne Hartley, farmer of a 130,000 bird operation and a 2,000 acre crop operation, uses cover crops in her fields during non-growing seasons to avoid nutrient depletion in her soil. She expressed that there were costs and benefits to the program. "It's going to cost us additional money in seed, in time, in fuel, in wear and tear on the equipment to put in, and it's not a crop we harvest," she said. "But, we do reap the benefits by

trapping those nutrients and having them available for the next crop come spring time."[131] Hartley doesn't get direct economic benefit, or profit, from the cover crops, but saving nutrients in the soil could mean a better yield the following season, and could reduce the need to purchase or apply fertilizer, thus saving costs.

Manure sheds provide another example of how practices that contribute to nutrient management can also provide numerous benefits for the farmer and their operation, and provide an example of practices that farmers are willing to implement, despite extensive initial investment costs. Marie Peterson, who has a 156,000 bird operation and has been involved in the poultry industry for over 20 years, has two manure sheds on her property that she uses to store litter from crust out and clean out before it is picked up and utilized by a crop farmer who uses the litter produced at Peterson's operation for his fields. "Those are significant expenses to build those buildings," she said of the sheds. "And they're not something that is generating any income. It's a cost of doing business, but it doesn't really make you any money per se."[132] While farmers don't acquire any income from installing the sheds, they protect manure from elements like wind and rain, inhibiting runoff. This is helpful to both the farmers and the environment; nutrients that would have otherwise been carried by elements into the surrounding environment and possibly contributed to nutrient pollution can instead be retained by the manure, making it a better, more viable fertilizer when applied to crops.

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[131] Personal Interview

[132] Personal Interview

Joanne Hartley emphasized this as well, saying, "It's an expensive investment—again, there were cost share dollars—but the benefits were there."[133]

Participants also cited heavy use pads as helpful, economically viable practices. Heavy duty concrete pads protect the soil around the entrances to chicken houses and manure sheds, meaning that less manure gets lost in transportation during crust out and clean out. This is a beneficial nutrient management practice because it adds a layer of protection between the earth and the manure, but it also helps the farmer by keeping the area clean, and preventing loss of valuable manure.

"Just from my experience in the industry, that's been an excellent practice," said Peterson, who's had twenty years' experience in the poultry industry, both as a farmer and working for an integrator.[134] "I love them because I can keep them perfectly clean…whereas if you just had regular stone or something like that sitting there, it's impossible to get the manure 100% out of the stone" (Personal interview Peterson).

William Tepner, a fifth generation farmer in southern Delaware, expressed that he and his family have been taking soil samples and conducting nutrient level testing on his crop operation for roughly thirty years, even before nutrient management practices became written into law. The motivation behind the testing was, at the time, economic. "It was an economic decision," Tepner said. "You don't want to over-

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[133] Personal Interview

[134] Personal Interview

apply. And if you want to grow your best crop, you need to have a balance of nutrients."[135]

The concept of economics driving best management practices and diligent nutrient management techniques was echoed throughout participants. But as much as the promise of economic return can drive practices, concerns over added cost also lead to pushback. When asked what the greatest struggle was in encouraging farmers to implement BMPs, Bob Nichols stated that economics presented a challenge. "If it's not economically feasible, if there's no return on your investment, that is the initial drawback of getting anything done," he said.[136] Peterson and Hartley echoed the sentiment.

The issue of expensive nutrient management practices is combatted in part by state and federal cost-share programs that can help mitigate implementation costs. The farmers expressed that cost-share programs through the conservation districts had made a significant difference in the process of implementing BMPs. According to James Wolfe, the conservation district will supply 75% of funding for the construction of manure sheds up to $30,000, 75% of the cost of composters up to $15,000, and 75% of the cost of heavy use pads up to $4,800.[137] The significant contributions of cost share money to costs of implementing BMPs make them feasible for farmers.

Cooperative Extension also helps mitigate the costs of responsible nutrient management by offering free or low-cost courses, events, and information. Courses

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[135] Personal Interview

[136] Personal Interview

[137] Personal Interview

required for nutrient management certification, for example, are given by Cooperative Extension at no cost to growers and applicators.[138] "Initial certification doesn't cost anything to the growers, other than their time," said Leah Fisher, Cooperative Extension agent. "We offer a lot of education information and activities that are either very inexpensive or free of charge."[139] Cost-share and free educational services mitigate the economic loss incurred in nutrient management practices, making them easier for farmers, and more likely to be implemented.

In addition, these classes and educational opportunities help farmers learn strategies not only for making compliance and nutrient management more manageable, but for improving operations on the farm. Keith Mitchell, a farmer of a 110,000 bird operation and a 10,000 acre crop operation, discussed the continuing education courses that farmers are required to attend to maintain their nutrient management certification. He stated that he goes to not only as many as he needs to keep up on credit, but as many as he can.[140] "I think they're worth your time, even if you don't need the credits," he said. "When you're raising chickens, you don't want to fall behind. If there's something new out there that other people are doing, you've got to try it. You've got to stay on top. That's how you're paid."[141] Mitchell stated that the profit he makes on each 7 week cycle of birds can fluctuate up to $10,000-12,000

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[138] Personal Interview

[139] Personal Interview

[140] Personal Interview

[141] Personal Interview

depending on yield.[142] Attending gatherings like Ag Week and educational courses offered by Cooperative Extension can help him and other farmers learn strategies to improve farm operations, and by extension yield and profit.

Wolfe summed it up by saying,

> I think the most, or the strongest driver behind [implementation of nutrient management practices] was the fact that all of these things could improve operations on the farm, so there was direct benefit. By having a manure structure, there was a place to store the manure when they were doing cleanouts, until it was going to be used in the fields. They could keep it dry; when it rained, it wasn't running off and leeching into the ground…They know what good practices are, and they're willing to do it, as long as it fits nicely into their operations. Cost share, what we offer or NRCS offers, allows it to get easily worked into their overall operations at an affordable level.[143]

Many nutrient management practices don't bring in direct profit, but can have significant economic benefits to farmers. The promise of economic gain, betterment of the operation, and assistance with initial costs have been expressed as driving factors in farmers' decisions to participate in best management practices and nutrient management education.

4.2.2 Fear of Repercussions for Non-compliance

The second factor that was found to influence farmers' decisions to implement BMPs and partake in nutrient management education was a pervading fear of being

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[142] Personal Interview

[143] Personal Interview

caught in non-compliance and experiencing repercussions, either financially or socially. Farmers demonstrated an eagerness to stay ahead of the curve in terms of nutrient management and compliance; several cited cases in the past where farmers had been fined after surprise inspections by regulatory agencies, been in the eye of public scrutiny, or become involved in regulatory lawsuits. In discussing regulation, Peterson said, "I do try to be in compliance and where I need to be because I don't want to get in trouble. I mean, I make good money with the chickens, but I can't afford a legal battle."[144]

In a study of manure management practices on farms in and outside of the Chesapeake Bay watershed, Savage and Ribaudo of the United States Department of Agriculture found that farmers who run animal operation in the Chesapeake Bay watershed are more likely to voluntarily implement best management practices than those who farm outside of it.[145] They found that this is influenced by almost thirty years of intense focus on nutrient management and water quality protection in the area, and that farmers are more likely to implement best management practices if "there is an expectation of future regulations," in an effort to stay ahead of the curve instead of having to build up to compliance later.[146] In other words, anticipation of regulation encourages the adoption of best management practices.

This is consistent with the information provided by farmers in this research. Farmers demonstrated an eagerness to demonstrate their compliance efforts; two

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[144] Personal Interview

[145] Savage, J. A. & Ribaudo, M. O., 2013

[146] Savage, J. A. & Ribaudo, M. O., 2013

poultry farmers stated that they had applied for CAFO permits even though their operations weren't legally required to, just because they wanted to err on the safe side of compliance and avoid conflict.[147]

4.2.3 Value of Land and Environmental Stewardship

The third motivation behind implementing best management practices was value of the land being farmed and a sense of environmental stewardship. Farmers' dedication to caring for the land was articulated not only in their own testimonies, but was described by regulators and members of the conservation districts and Cooperative Extension.

"They want to take care of the environment," said Peterson of her fellow farmers. "They do want to be mindful, because really, the land takes care of them, so they know they have to take care of the land."[148]

"A lot of it is they have a stewardship mindset," agreed James Wolfe. "That land was passed down to them to use, and they want to make sure it's passed down for future generations. It's their livelihood, after all."[149]

4.3 Successful Strategies in Improving Nutrient Management in Delaware

This research found three main factors that contributed to the improvement and adoption of nutrient management practices by the agricultural community, as well as

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[147] Personal Interview

[148] Personal Interview

[149] Personal Interview

to the improvement of the relationship between Delaware regulators and farmers. These factors are:

- Strong science and educational outreach
- Collaborative processes and open communication.
- Inclusion of a middleman

4.3.1 Strong Science and Educational Outreach

Participants indicated that incorporation of reliable science was very influential in understanding nutrients and developing strategies for managing their release. Most importantly, science played a key role in encouraging farmers to understand the role of agriculture in nutrient pollution and to adopt practices.

Bob Nichols, who has more than 20 years' experience in the agricultural field, expressed that scientific research has been the first priority in understanding how nutrients move through the environment, and developing methods for handling them that influence the agricultural community.[150] For example, he discussed the *Pfiesteria* outbreaks in North Carolina and then in Maryland. "Prior to that, science said that phosphorous is a soil bound nutrient," he said.[151] After the *Pfiesteria* outbreak, he said, "science took another look and said, okay, perhaps there's something else going on here. And science caught up and said hey, we now realize, at certain levels of phosphorous in the soil, you can get saturation, and you can get movement of

[150] Personal Interview

[151] Personal Interview

phosphorous away from the soil particles."[152] The connection between a farmer spreading natural manure and massive fish kills is not readily evident; there are several ecological steps that connect the two: manure to nutrients, nutrients to algal growth, algal growth to *Pfiesteria* population boom, *Pfiesteria* population boom to fish mortality. Without understanding these connections, it can be difficult for people who are in their minds, only doing their job and providing for a nation, to accept a role in the degradation of the environment on which they rely.

With the understanding of phosphorous mobility, Nichols said, universities and private labs changed manure application recommendations from nitrogen-based recommendations to phosphorous-based recommendations.[153] According to Sharpley, Herron and Daniel (2007), poultry manure has a narrower nitrogen to phosphorous than most crops require; these means that applying enough manure to fulfill crop nitrogen needs will provide too much phosphorous for the crops to uptake. Previous manure application recommendations were nitrogen-based; with improved scientific research into phosphorous mobility, however, recommendations changed to be phosphorous based on manure application, and then encouraged supplementing the nitrogen deficit left by reduced manure application with chemical fertilizer.[154]

Science played a key role not only in the development of better nutrient management practices but in encouraging farmers to implement them, and in improving the relationship between farmers and regulators.

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[152] Personal Interview

[153] Personal Interview

[154] Personal Interview

"Farmers get their backs up when they hear 'regulations,' but they're also willing to learn, and once you show them with science, hey—this is what works, this is what's going to benefit you—that makes such a big difference than writing regulation and waiting for somebody to make a mistake…it's an amazing difference," said Joanne Hartley.[155]

"The whole process has been one of education with the farming community, and it has definitely worked," Hartley continued.[156] She discussed an example from her own farm; when she and her family began growing crops in the 1980s, they were unaware of best manure application strategies, and ended up with a large yield of weak crops springing up from too much nutrient stimulation, instead of fewer, sturdy crops.[157] Hartley's husband and father-in-law, who worked the farm with her, contacted an agent at Cooperative Extension who came to the farm and showed the farmers how to set up and calibrate their manure spreader, and how to look at soil tests to determine the correct amount of nutrients and manure to apply.[158] "That was a big learning [moment] for us at first, that first time," Hartley said. "The next time they applied manure, they did it in a whole different way."[159]

Hartley discussed Cooperative Extension as a valuable and trusted resource of scientific information. "We've relied on them for years, for the science behind any

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[155] Personal Interview

[156] Personal Interview

[157] Personal Interview

[158] Personal Interview

[159] Personal Interview

time they're recommending a change," Hartley said.[160] Hartley emphasized that this reliance on science is huge in connecting to farmers and encouraging changes in practices.[161] She stated that, sometimes, farmers feel that environmental organizations or regulatory agencies look at issues and ascribe an arbitrary or 'one size fits all' solution to environmental issues without understanding the individual needs of different operations, or without considering the complicated processes that farming entails.[162]

"You need to fall back on the educational process, because there's some out there who don't care about what the [research] shows, they just have is in their minds that, oh, a 100 foot buffer is what you need," she said, discussing pushes for environmental protection methods by environmental groups; "but wait a minute, you've got to draw the line between politics and let the science rule."[163]

4.3.2 Collaborative Processes and Open Communication

Collaborative processes bringing together stakeholders in nutrient management has been instrumental in increasing nutrient management regulation in Delaware, and in promoting cooperative relationships between farmers and regulators. The Delaware Nutrient Management Commission, created in 1999, is the most significant example of this. As stated above, the DNMC was designed to include representatives from the

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[160] Personal Interview

[161] Personal Interview

[162] Personal Interview

[163] Personal Interview

various sectors of the farming community, from regulatory agencies, from Cooperative Extension, and others.

The members of the DNMC work together to stay up to date on relevant science, address issues in nutrient management, and craft relevant policy. The collaborative process provided by the DNMC was the key to implementation. "The fact that ag[sic] had an input on how the regulations were written and how they were going to be implemented made it more palatable," said Nichols.[164] "It was less of a 'we're telling you' and in some cases, they were telling us what could work."[165]

"Who of us wants to be messed with?" said Roger Carson of DNREC when he was asked what he thought challenged the relationship between farmers and regulators.[166] Many participants expressed that tension between farmers and regulators sometimes stemmed from the belief of one side that the other didn't understand their position.

"In regulatory agencies, you just have people who think everything you do has to have a fine attached to it, and this is the way to get people to come into compliance," said one poultry farmer.[167] This hearkens back to the finding that one motivating factor behind implementation of nutrient management practices among farmers is concern over being caught in non-compliance; all four farmers interviewed and those casually participating in discussion at conservation districts or outside of

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[164] Personal Interview

[165] Personal Interview

[166] Personal Interview

[167] Personal Interview

formal interview settings expressed or implied worry that some regulatory agencies are out to tighten regulation and force compliance without fully understanding how agriculture works, technically and economically.

The fact that different stakeholders were represented on the Commission addressed this issue by ensuring that all voices were heard in crafting policy. Carson echoed that the DNMC encouraged the growth of a better relationship, and made farmers more willing to take best management actions.[168] The DNMC, he said, became a system of "peers regulating peers"[169]; having people who knew and worked in the agricultural industry on the Commission gave it legitimacy in the agricultural community. Nichols added, "Just the mere fact that half of the Commission was made up of agriculture and land based people, who made their living from the land—that made the program work. That single factor."[170]

Leah Fisher, who works closely with poultry farmers on nutrient management and who emphasized Cooperative Extension's positive relationship with the farmers, also expressed the importance of collaboration on the DNMC.[171] She said, "For the most part, I think our growers have been willing to make changes that they need to because they had a voice when the whole thing came down. And that's really

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[168] Personal Interview

[169] Personal Interview

[170] Personal Interview

[171] Personal Interview

important, is that the agricultural community is heard. And so, that's why we have the Delaware Nutrient Management Commission."[172]

One farmer, who is also a poultry representative on the Delaware Nutrient Management Commission, explained the way the DNMC helped alleviate the tension between the farming community and regulatory agencies after the Delaware Nutrient Management Law was passed in 1999. "There was pushback," the participant said.[173] "But in the process of setting up the Nutrient Management Commission, they made it a diverse group…So you get better interaction, and it can't be accused of being one-sided."[174]

Farmer William Tepner emphasized that one way to continue improving the relationship between farmers and regulators is to work together to promote a positive image of agriculture.[175] He said that, when it comes to nutrient management, agriculture is sometimes treated "like the red-headed step-child," standing out as the bad guy in the environmental conflict.[176] Instead, he encouraged regulators to communicate to the public when the agricultural industry makes improvements or progress, and to promote a positive image.[177] Increased communication between the two stakeholders can achieve this.

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[172] Personal Interview

[173] Personal Interview

[174] Personal Interview

[175] Personal Interview

[176] Personal Interview

[177] Personal Interview

4.3.3 Incorporating a Middleman

A major finding of this research was the positive influence of a "middleman" organization that facilitated relationships between farmers and regulators. The middleman groups that this research found most prominent and effective were University of Delaware Cooperative Extension and the Kent and Sussex Conservation Districts. These groups have been successful in maintaining positive, trusting relationships with the farming community, and have established reputations as reliable, non-regulatory sources for help and education. Because of these strong relationships, Cooperative Extension and conservation districts have acted as middlemen between farmers and regulators, thus making nutrient management less punitive and more cooperative.

Participants unanimously agreed that the farming community and Cooperative Extension have a beneficial and productive relationship that contributes positively to nutrient management in Delaware. Leah Fisher, Cooperative Extension Agent, stated that the successful relationship between farmers and Cooperative Extension is due to largely to the fact that it is purely an educational group, with no ties to regulation.[178] She said, "We are recognized as non-regulatory, science-based…we provide science-based information that's supposed to be non-biased."[179] She continued, "We are not enforcing the things that we're teaching. We're here just to educate people based on what the science says."[180] As discussed above, farmers expressed concern or fear of

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[178] Personal Interview

[179] Personal Interview

[180] Personal Interview

being caught in non-compliance, even if they are doing everything that, within their knowledge, they need to be doing. This fear could prevent farmers from reaching out to agencies with concerns or issues with farm operations; calling attention to an issue carries the risk of fines and repercussions.

Carl Silverstein of the Sussex Conservation District also brought up this benefit of collaboration between DNREC, the conservation district, and farmers. "We can work as a liaison, and I'll give you an example," he said.[181] He went on to describe a time that DNREC had received a public complaint, stating that a farmer was leaving poultry mortalities laying on the ground. An agent from DNREC asked Silverstein to check out the situation; it turned out that the farmer was cleaning out a house, and laying the mortalities out while preparing to dispose of them properly.[182] By asking a representative of the conservation district, non-regulatory personnel, the situation automatically feels friendlier and raises less cause for defensive tension. Silverstein explained that the conservation districts have a good relationship with farmers by nature; they provide a lot of services—writing plans, helping implement best management practices, troubleshooting farming issues—that make farmers' lives less complicated, and they do it without the awkward power balance of a regulatory agency.

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[181] Personal Interview

[182] Personal Interview

4.4 Remaining Challenges

Participants were asked to identify any remaining challenges to nutrient management in Delaware's agricultural industry. The most prominent issues expressed either directly or through implication were:

1. Keeping up with advancing technology
2. Persisting discontent with the EPA
3. Dealing with natural factors
4. Improving public awareness

4.4.1 Keeping up with Advancing Technology

Several participants indicated that keeping up with scientific and technological advancements was a challenging part of nutrient management, either because of difficulty in learning to use technology, or of the sluggish regulation process involved in approving nutrient management techniques.

Fisher said, "It's difficult to keep up with the technologies. There are a lot of technologies out there I think could do us a lot of good, but there's definitely a learning curve for implementing technologies."[183] She cited examples of crop-targeting technologies and advanced soil monitoring instruments that could be helpful, but require training and technical understanding.[184]

Similarly, Carl Silverstein discussed mortality freezers as a means of replacing composters.[185] Freezers may be easier for farmers to manage than mortality

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[183] Personal Interview

[184] Personal Interview

[185] Personal Interview

composting; composting requires layering and turning the mortalities, a carbon source, and manure, while a freezer requires minimal effort.[186] Farmers would simply place mortalities in the freezers until they could be picked up by a renderer.[187] However, freezers are expensive, and regulation lags may prevent farmers from being able to access cost-share funds to purchase and install them.[188] "We end up a year or two behind because it's a new technology," said Silverstein, referring to the approval process of making nutrient management strategies available for cost-share funding.[189]

As stated above, the education process is vital in furthering nutrient management; a remaining question is whether existing education and regulation strategies can keep up with advancing nutrient management technology well enough to maximize nutrient management to its full capacity.

4.4.2 Persisting Discontent with the EPA

Participants of all backgrounds either directly stated or indirectly implied that a pervading challenge in the nutrient management process was persisting discontent with the United States Environmental Protection Agency. Under the Clean Water Act, the EPA has the ability to interfere in state processes if the targets of the Chesapeake Bay TMDL aren't met.[190] "The last thing that farmers want is for the EPA to come

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[186] Personal Interview

[187] Personal Interview

[188] Personal Interview

[189] Personal Interview

[190] United States Environmental Protection Agency, 2013

over and take jurisdiction over DNREC because we didn't meet our water quality nutrient reductions based on our WIP [Watershed Implementation Plan]," said one participant.[191] Participants expressed the impression that the EPA gets involved and exercises control over nutrient management in Delaware without understanding the specifics of the agricultural industry, and the costs their programs are incurring on farmers.

"The EPA came in, guns blazing, and said, 'you need this, this, and this,'" said one farmer with frustration, referring to nutrient management regulation development in the late 90s and early 2000s.[192]

Participants from state agencies hesitated when asked about the relationship between the EPA and the farming community, and between the EPA and Delaware state agencies. "EPA needs to get comfortable with us running the program," said one Delaware government agent.[193] He expressed that there is perceived doubt in the EPA and in environmental groups that the DDA is capable of regulating the agricultural industry; he said they think it's a matter of "the fox guarding the henhouse."[194] However, the agent expressed his belief that the DDA is better suited to deal with regulation in the agricultural community, because they are more familiar with the workings of agriculture, and how to best work within the capacity of the industry to get results. "We're not so much about fines as we are about—you have a problem, fix

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[191] Personal Interview

[192] Personal Interview

[193] Personal Interview

[194] Personal Interview

it. We don't really want your money, we want the problem solved. And the ag community understands that," he said.[195]

Another poultry farmer echoed this sentiment: "Sometimes people at EPA may come across as [having] and attitude of 'carry a big stick' and say, 'you will do this or you won't do this and we'll fine you ten grand a day."[196] She discussed that this abrasive approach isn't "attractive or palatable" to farmers[197] who are already afraid of being fined for doing something they may or may not have known was wrong.

One conservation district representative stated that the general feeling in the farming community is negative towards the EPA.[198] He described the EPA's jurisdiction as slowly broadening, in a process he called "mission creep."[199] He echoed the sentiment that the EPA has its hands in Delaware regulation in an inefficient way. Instead, he said, "I think there's much more potential in DNREC [than in EPA regulation] because it's local. Especially in a small state like Delaware, you know the people that you're working with generally….The federal agencies have taken on their own identity and they're a creature of themselves."[200]

Overall, participants indicated that there is a disconnect and a distrust between farmers and the EPA, and between state agencies and the EPA, both of whom feel that

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[195] Personal Interview

[196] Personal Interview

[197] Personal Interview

[198] Personal Interview

[199] Personal Interview

[200] Personal Interview

the federal agency is too far removed to understand the consequences of the regulations they impose or threaten to impose.

4.4.3 Dealing with Natural Factors

Perhaps the most problematic player in nutrient management is just the party everyone is trying to save: nature. Nutrient transport through the environment can occur in several ways, including leaching and erosion, and plants don't always take up as much nutrient as needed at the exact time needed, leading to nutrient loss to the environment.[201]

Nitrogen is a more volatile element; nitrogen gas can be released to the atmosphere, while mineralized nitrogen and sediment bound nitrogen can be carried off by wind and water.[202] "We're still not good at nitrogen management," said Fisher.[203] "Nitrogen's just inherently leaky…nitrogen is so tricky because of the weather. It can be too wet, it can be too cold, it can be too hot, and all of that really plays into nitrogen management."[204] Nitrogen loss to the environment can depend on a lot of environmental factors that aren't always predictable; this creates a significant challenge in managing it.

Where nitrogen is flighty, phosphorous can be stubborn. While phosphorous loss to the environment from present nutrient application is a significant issue,

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[201] Volk, J., 2015

[202] Volk, J., 2015

[203] Personal Interview

[204] Personal Interview

management of phosphorous is made more challenging by the presence of historic phosphorous levels, or long-standing phosphorous pollution that continues to leech out of groundwater from agricultural activity in the past. Roger Carson expressed that this was a particular challenge; farmers can't just stop applying phosphorous, but even if they did, existing phosphorous saturation in the soil would continue to cause issues.[205]

Fisher said, "The challenge is figuring out how we can manage losses of phosphorous to the water that are related to historical applications of P."[206] She smiled wryly and continued, "If that was an easy answer, I wouldn't have job right now."[207]

Given the myriad chemical, biological, geological factors that influence nutrient transport throughout the environment, and the complex environments that react to these nutrients, regulating nitrogen and phosphorous pollution is inherently difficult, before social factors of management are even introduced.

4.4.4 Improving Public Awareness

A final challenge that appeared prevalent in participant testimony was a frustration with public perception of the agricultural industry. Public complaints put pressure on farmers and make them feel scrutinized or targeted when complaints turn out to be over completely legal matters; one example is the one mentioned earlier by

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[205] Personal Interview

[206] Personal Interview

[207] Personal Interview

Carl Silverstein of the farmer who was laying out chickens to be composted, but was accused of a citizen of leaving mortalities out unlawfully.[208]

Marie Peterson, a poultry farmer, said, "You have a public that doesn't really understand what it takes to produce their food today, because they're so disconnected from it."[209] Residents of agricultural areas may make complaints to regulatory agencies about odors typical of agriculture, or about farm practices they see and don't understand. These complaints can put stress on the relationship between farmers and regulators because they mean increased visits or inspections to investigate claims, and make farmers feel targeted.

Increased community awareness and education through groups like Cooperative Extension and educational institutions can help mitigate this. Programs like University of Delaware's Ag Day, an annual community event centered on agriculture, environmental conservation, wildlife, and all other land-based topics, can connect Delaware residents with relatable, solid information about the agricultural industry they rely on, and can foster a deeper understanding and appreciation for everything that goes into agriculture. In turn, harmony between the farming community and the residential community may mean less tension between farmers and regulators.

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[208] Personal Interview

[209] Personal Interview

Chapter 5

DISCUSSION

5.1 Questions for Future Research

This project explored the driving factors behind nutrient management development and implementation in regards to Delaware's agricultural industry; the next step is to investigate questions of compliance and reconciling externalities.

Questions for future research ask, numerically, how effective the strategies discussed in this paper have been by determining the number of farmers who are in full compliance with the Delaware Nutrient Management Law, and who implement the nutrient management practices investigated here. This information can provide quantitative evidence that the strategies discussed here have been successful in encouraging and maintaining compliance.

Unfortunately, this research encountered some difficulty in answering questions on compliance rates. Information on specific numbers of best management practices or completed nutrient management plans were not located, and participants didn't discuss compliance rates, or methods for ensuring that farms are in compliance with the Delaware Nutrient Management Law. This could be because compliance rates are not ideal, or because they are not recorded in totality. Further research may reveal that compliance and BMP implementation rates aren't measured or maybe aren't readily enforced. This could be due to a lack of manpower within public agencies; monitoring a couple thousand operations takes a lot of time, resources, and paper work.

A further question, then, would ask how support in enforcement can be increased, and where that support would come from. As Delaware struggles to meet

the limits of the Chesapeake Bay TMDL and the requirements of its Watershed Implementation Plan, it is clear that there is still some progress to be made in reconciling the negative external costs, or externalities, of nutrient pollution. Who will pay for increased attention to compliance, increased cost-share, newer technologies, or any other nutrient management strategies that need to be employed for Delaware to meet its water quality goals? Stakeholders include farmers and consumers, who both benefit from the nutrient-intensive industry and could be argued responsible for handling its externalities. Stakeholders also include a crucial party: integrators. Further research may look into the role of integrators, and their economic and political strength, and whether they should be contributing to the costs of nutrient management, and paying to balance out the externalities resulting from nutrient pollution in correlation with their industry.

In addition, future research may examine the perspectives of outside stakeholders not covered in this research, such as consumers, integrators, EPA agents, and non-governmental environmental conservation organizations.

This research covered success and challenges in the development of nutrient management in Delaware; future research may investigate quantitatively how these strategies have worked, and who should pay for the work that is left to do.

5.2 Conclusion

The purpose of this research was to provide a comprehensive overview of how nutrient management has developed over time, who is involved in it, what specific practices are used to achieve it, and what strategies have been successful in promoting the progress of nutrient management. In the whirlwind of information that surrounds nutrient management in Delaware agriculture, this research wanted to take an on-the-

ground, hands-on approach to understanding the processes behind nutrient management in Delaware agriculture, and the people involved in them.

Several events have impacted the development of nutrient management, including national movements for soil conservation and water quality improvement, as well as public health and economic concerns connected to *Pfiesteria piscicida*. However, the regulations resulting from these events introduced time-consuming, cost-intensive practices to farmers, creating tension between regulators and the farming community. By utilizing strong science and education, designing collaborative processes like the Delaware Nutrient Management Commission, and embracing non-regulatory middlemen, stakeholders have been able to drive nutrient management forward.

Understanding the driving forces that influence farmer implementation of BMPs and pairing that with the strategies described above, regulators can form stronger, more collaborative relationships with farmers to encourage stronger nutrient management practices.

This research gathered firsthand testimony from people directly involved in nutrient management in Delaware. By compiling qualitative data, this research has brought to light significant strategies, struggles, and successes experienced by those involved in nutrient management and agriculture in Delaware. The information provided and perceptions expressed by participants can serve as a base for quantitative research on changes in nutrient management in Delaware over time.

This research also carries universal implications for a broad range of environmental conflicts. In this situation, strong science and stakeholder collaboration were essential in making progress; in addition, the presence of an intermediary third

party between dissenting stakeholders (in this case, farmers and regulators) was found to be helpful and effective. It is likely that these strategies can be applied to other environmental conflicts to achieve stronger resource management.

Nutrient management in Delaware is complex, from the perspectives of natural science and social science alike. While questions of resolving externality and enforcing compliance still remain, Delaware stakeholders in nutrient management have made tremendous progress over the past thirty years in the way that they relate to each other and work collaboratively to achieve stronger nutrient management.

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Appendix A

INTERVIEW SCRIPT FOR NUTRIENT MANAGEMENT RESEARCH PROJECT: FARMERS

Institutional Review Board
Principal Investigator: Caren Fitzgerald

Thank you for meeting with me today. As (insert connection) may have informed you, I am a senior undergraduate at the University of Delaware. I'm studying the development of nutrient management programs in Delaware for my senior thesis. I am interested in learning about the ways that farmers work with parties like the Department of Natural Resources and Environmental Control and the Delaware Department of Agriculture on these management programs.

I am interviewing farmers like yourself because I want to understand how nutrient management requirements affect farmers and their day-to-day business operations, and how these requirements and farmers' perceptions towards them have changed over time.

Please know that any information you share or comments you make will be kept anonymous.

I really appreciate your willingness to talk with me, and am excited to hear what you have to say.

Getting to Know You Questions

- What's your experience with farming in Delaware?
    - How long have you worked in agriculture?
    - What type of operation do you own/operate (poultry, grain, vegetable, multiple, etc.)?
- What is your current production like?
    - Bird count, crop yield, if available
    - Integrator?
    - Are you a classified Concentrated Animal Feeding Operation?
- Have you farmed in any other states?
    - If so, we can later discuss this in comparison to Delaware.

Litter Management

- How frequently do you crust/clean out your house?
- Where does litter from your operation generally end up?

    - Spread on own land, storage, given to local farmers, pelletizing plant, etc.?
- What kind of nutrient management programs do you take part in?
    - Delaware Nutrient Management Program (Level of certification)
    - Animal Waste Management plans
    - Comprehensive Nutrient Management Programs
    - Best management practices
- Do you participate in cost share programs through DDA or NRCS?
- How do you feel about Delaware's nutrient management programs? Are they effective?
- Have your litter management practices changed over the time you've been farming in Delaware? How?
    - What were the reasons for these changes?

Perceptions of Nutrient Management

- How do you feel about the level of attention given to litter and nutrient management, in regards to Nitrogen and Phosphorous in particular, in Delaware?
    - Ex: Is there too much focus on it? Too little? The right amount?
- Is it difficult to keep up with requirements of state-mandated nutrient management programs/activities?
- What, if any, farming organizations or relevant non-profits do you participate in or support?
    - What is the focus regarding nutrient management like in these organizations?

Historical Questions

- How has the farming industry in Delaware changed in general over the time you've been farming here?
- How have perceptions of nutrient management changed within the farming community?
- How would you describe the relationship of the farming community with government regulatory agencies?
    - DNREC? DDA? EPA?
    - Have these relationships changed over time? How so and why?
    - What strategies have been most effective in maintaining these relationships?
    - Do you think anything can be done to improve these relationships?

If there is any further information (including additional comments or concerns) or any resources you think I should be aware of going forward, please let me know.

Appendix B

INTERVIEW SCRIPT FOR NUTRIENT MANAGEMENT RESEARCH PROJECT: PUBLIC OFFICIALS

Institutional Review Board

Principal Investigator: Caren Fitzgerald

Thank you for meeting with me today. As we discussed (via email, over the phone, etc.), I am a senior undergraduate at the University of Delaware. I'm studying the development of nutrient management programs in Delaware for my senior thesis. I am interested in learning about the ways that parties like (insert participant organization) work with farmers to make these management programs successful.

I am particularly interested in the development of waste and nutrient management programs in regards to Delaware agriculture. I want to understand what the difficulties and successes were in implementing these programs, how (insert participant organization) and other entities work with farmers to overcome roadblocks, and how the relationship between Delaware farmers and regulators has progressed and will continue to grow over time.

Please let me know if you wish for anything you say to be kept off the record.

I really appreciate your willingness to talk with me, and am excited to hear what you have to say.

Getting to Know You Questions

- What is your position in your organization, and what does that job entail?
- How are you involved with nutrient management in Delaware?
- How long have you worked in this field?
- Have you worked for any other relevant organizations? If so, we can discuss any relevant information.

Nutrient Management

- What do you think are some of the most successful nutrient management programs and practices in Delaware overall? In particular regards to agriculture?
    - What factors do you think lead to the success of these programs?
- What are some of the biggest challenges in regulating the agricultural industry?

    - Have these challenges lessened, increased, or remained the same over time?
    - How so, and why?
- How does nutrient management in Delaware today vary from what it was 20 or 30 years ago?
- Does variability between state and federal regulation affect this process?
    - If so, how?
- What role does the state's relationship with integrators play in nutrient management? Should it play a role?

Perceptions of Agricultural Nutrient Management

- How do you feel about the level of attention given to nutrient management, in regards to Nitrogen and Phosphorous in particular, in Delaware?
    - Ex: Is there too much focus on it? Too little? The right amount?
- How would you describe the relationships between the farming community and government regulatory agencies like DNREC, DDA, and the EPA?
    - Have these relationships changed over time? How so and why?
    - What strategies have been most effective in improving and maintaining these relationships?
    - Do you think anything can be done to improve these relationships?

If there is any other information or any resources you think I should be aware of going forward, please let me know.

Appendix C

INTERVIEW SCRIPT FOR NUTRIENT MANAGEMENT RESEARCH PROJECT: OTHER PARTICIPANTS

Institutional Review Board

Principal Investigator: Caren Fitzgerald

Thank you for meeting with me today. As we discussed (via email, over the phone, etc.), I am a senior undergraduate at the University of Delaware. I'm studying the development of nutrient management programs in Delaware for my senior thesis. I am interested in learning about the ways that parties like (insert participant organization/relevant party) work with farmers to make these programs successful.

I am particularly interested in the development of waste and nutrient management programs in regards to Delaware agriculture. I want to understand what the difficulties and successes were in implementing these programs, how (insert participant organization) and other entities work with farmers to overcome roadblocks, and how the relationship between Delaware farmers and regulators has progressed and will continue to grow over time.

Please let me know if you wish for anything you say to be kept off the record.

I really appreciate your willingness to talk with me, and am excited to hear what you have to say.

Getting to Know You Questions

- What organization(s) are/were you a part of, and what is/was your position within that group?
- How are/were you involved in nutrient management in Delaware?
- How long have you worked/did you work in this field?
- What other relevant experience/education do you have pertaining to nutrient management and/or agriculture?

Nutrient Management

- What do you think have been some of the most successful nutrient management programs in Delaware overall? In particular regards to agriculture?
    - Why?
    - What factors do you think lead to the success of these programs?

- What are some of the biggest challenges in regulating the agricultural industry?
    - Have these challenges lessened or increased over time?
    - How so, and why?
- How does nutrient management in Delaware today vary from what it was 20 or 30 years ago?
- How have political groups, non-profit organizations, and other non-governmental organizations played a part in the development of agricultural regulation?

Perceptions of Agricultural Nutrient Management

- How do you feel about the current level of attention given to nutrient management, in regards to Nitrogen and Phosphorous in particular, in Delaware?
    - Ex: Is there too much focus on it? Too little? The right amount?
- How would you describe the relationships between the farming community and government regulatory agencies?
    - DNREC? DDA? EPA?
    - Have these relationships changed over time? How so and why?
    - What strategies have been most effective in maintaining these relationships?
    - Do you think anything can be done to improve these relationships?
- How do non-governmental organizations affect perceptions of nutrient management in Delaware?

If there is any further information or any resources you think I should be aware of going forward, please let me know.

Appendix D

IRB CONSENT FORM

Description of Research

The goal of this research is to understand how Delaware farmers and regulators implement and practice environmentally responsible nutrient management relevant to the agricultural industry, and to study the successes, challenges, and changes in dynamic that have occurred in regards to this process over time. Information gathered in this research will be used to complete a senior thesis at the University of Delaware.

You have been chosen to participate in this study because:

1. ____You are a citizen involved in the agricultural industry.
2. ____You are employed by a public agency whose jurisdiction covers issues related to the agricultural industry.
3. ____You are employed by a public agency whose jurisdiction covers issues related to environmental quality and/or nutrient management.
4. ____You are involved in a non-governmental organization that is involved with subjects relevant to this study.
5. ____You have experience and expertise directly related to nutrient management, agriculture, and/or environmental quality.

You will be asked questions regarding the Delaware agricultural industry, manure management, and nutrient management, and your perception of issues related to these topics. The duration of this interview will likely be sixty minutes.

Conditions of Participation

1. Participation is voluntary, and you reserve the right to end the interview at any time.
2. There will be no repercussions for denial of participation or termination of the interview.
3. You may choose to speak on or off the record at any time.
4. Comments will be kept anonymous, separated from interviewee identity. Public officials may give permission to be cited.

____ I have read this page.

Risks and Benefits
There are no foreseeable risks associated with participation. Participants may benefit from the opportunity to express views associated with agriculture and nutrient control in Delaware, and contribute to the improvement of environmental management.

Financial Considerations
You will not be compensated for your participation in this research.

Contacts
For questions concerning this research, contact:

Caren Fitzgerald, Principal Investigator
Department of Geography
University of Delaware
908-907-7883 cafitzge@udel.edu

For questions concerning your rights as a research participant, contact:

Clara Simpers
Institutional Review Board
University of Delaware
302-831-2137

Consent Signatures

____ I have read this form and accept the conditions of participation.

____ I give my consent to be interviewed and to have this interview audiorecorded.

____ I give consent to be interviewed and allow notes to be taken during this interview.

Participant Name (print): _____

Participant Signature: _____

Date: _____

Appendix E

LIST OF ABBREVIATIONS

- **BMP—**Best Management Practice
- **CAFO—**Concentrated Animal Feeding Operation
- **CNMP—**Comprehensive Nutrient Management Plan
- **DDA—**Delaware Department of Agriculture
- **DPI—**Delmarva Poultry Industry
- **DNMC—**Delaware Nutrient Management Commission
- **DNREC—**Delaware Department of Natural Resources and Environmental Control
- **EPA—**United States Environmental Protection Agency
- **EQIP—**Natural Resources Conservation Service Environmental Quality Incentives Program
- **NRCS—**Natural Resources Conservation Service