An Unsustainable Path

Why Maryland's Manure Pollution Rules Are Failing to Protect the Chesapeake Bay

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Cover image: *Sediment plumes around Horn Point on the Choptank River, near Cambridge.* Photo courtesy of Jane Thomas, IAN Image Library (ian.umces.edu/imagelibrary/).

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– U.S. Environmental Protection Agency,
on management of federal land in the Chesapeake Bay region

In areas of intensive animal production, the long term goal must be to match manure [phosphorus] production with local crop [phosphorus] requirements, or to find alternative uses for the manures outside the farm boundary.

– SERA-17, the Organization to Minimize
Phosphorus Losses from Agriculture

Executive Summary

Phosphorus from manure applied to farmland is a major source of pollution in the Chesapeake Bay. Intensive chicken production, particularly on Maryland's Eastern Shore, generates large volumes of manure. Growers and farmers often spread this manure on their fields as fertilizer, but when applied in excess, the nutrients that make manure useful for fertilizing crops also contribute to dead zones in the bay.

A number of experts and authorities—including the U.S. Environmental Protection Agency and the scientists who helped design Maryland's phosphorus management rules—agree that Maryland's current approach to protecting the bay from phosphorus pollution is inadequate.

Reducing phosphorus pollution is essential to restoring the health of the bay. A key step toward this goal is ending the practice of spreading chicken manure on farmland that is likely to pollute water with phosphorus.

Pollution has taken a heavy toll on the bay.

- A "dead zone" covers a large portion of the bay each summer. Nutrient-fed algae blooms flourish briefly and then die, consuming vast amounts of oxygen as they decay. As a result, levels of dissolved oxygen in the water drop below the concentration needed to support fish, crabs and oysters.

- Algae blooms block sunlight, killing underwater grasses and destroying valuable habitat. The bay has less than half the acreage of underwater grass needed for a healthy ecosystem.

- Nutrient pollution, along with overharvesting and disease, has hastened the decline of major fisheries such as oysters and crabs.

Pollution from agriculture accounts for 41 percent of the phosphorus that enters the bay from Maryland. Manure contains high levels of nitrogen and phosphorus, making it useful as a fertilizer, but the ratio of nitrogen to phosphorus is such that if manure is applied to meet the nitrogen requirements of a crop, phosphorus is over-applied. This excess phosphorus escapes from farm fields and into nearby waterways.

Large-scale chicken growing on Maryland's Eastern Shore generates high volumes of manure that contain far more phosphorus than can be used by crops nearby.

- The 296 million broiler chickens raised in Maryland in 2007 generated approximately 550,000 tons of "chicken litter," manure mixed with bedding and feathers.

- This chicken litter contained far more phosphorus than is required by crops in major chicken-producing counties in Maryland.

- Soil test data from 2002 show that more than 60 percent of soil samples from four Maryland counties—where tens of millions of chickens are raised annually—were saturated with phosphorus. At such high saturation levels, phosphorus is more prone to dissolve in water and pollute the bay.

Maryland's current rules allow farmers to spread manure on fields where phosphorus is likely to run off and pollute the bay.

- Maryland requires farmers to use a test called the phosphorus site index (P-index) if soil is found to be overloaded with phosphorus. The P-index was meant to be a tool that would allow farmers to evaluate the water pollution risk of applying manure to the field.

- The P-index approach does not address the state's long-term phosphorus problem, since it allows farmers to use some fields as dumping grounds for excess manure, even if they are already loaded with phosphorus.

- Maryland's current P-index underestimates the extent to which phosphorus may escape from a field into nearby water bodies through subsurface water flows in some regions of Maryland, especially in the marshy Eastern Shore.

- Phosphorus may also escape from fields that have seemingly safe levels of phosphorus—fields below the P-index threshold—but Maryland's current rules do little to control this source of pollution.

- Application of the P-index appears not to be solving the problem of phosphorus pollution into the bay from agriculture. In at least one major chicken-producing region, water quality has not improved since Maryland adopted its current rules. In the Choptank River, phosphorus levels have risen by an average of 1.9 percent per year from 2000 to 2008. The Choptank drains parts of Caroline, Dorchester, Queen Anne's and Talbot counties, where large-scale chicken production generates hundreds of thousands of tons of excess manure and there is relatively little residential development.

Maryland produces far more phosphorus-laden manure than crops in the region can use. The state needs to keep phosphorus out of the bay, and it needs a long-term solution for ending phosphorus build-up in soil.

- Maryland should end land applications of chicken litter that endanger the health of the bay by replacing the current inadequate rules for phosphorus application with more effective ones. Maryland should phase in standards that prevent more phosphorus from being applied to cropland than crops need.

- The volume of manure in Maryland that needs to be disposed of through land application must be brought into balance with the amount of nutrients that crops need. Options include processing more manure into pelletized fertilizer and transporting more manure out of the region.
- Any alternative plan for disposing of chicken manure should require poultry producers such as Perdue to take responsibility for the pollution that their activities produce.

Introduction

Throughout its history, Marylanders and residents of the Chesapeake Bay region have had two very distinct and opposing relationships with the bay.

For centuries, the bay has been central to the economy and culture of Maryland. It has been a key transportation corridor, supporting economic activity and development. Thousands of families earned a living harvesting the bay's bounty and selling it to citizens living in the region. The annual fishing and crabbing cycle shaped life in towns along the shores of the bay, the same towns to which tourists now flock, hoping to catch a glimpse of these traditional industries.

At the same time that the bay has been honored for the resources it provides to Maryland, it has also provided a convenient place to dump waste. Industrial facilities and electrical equipment released PCBs, which are persistent toxic chemicals, into groundwater that seeped into the bay. Sewage treatment plants released poorly treated effluent into many of the major tributaries of the bay, while septic systems leached pollution from the shoreline. As scientists and the public became aware of the damage to the bay's ecosystems caused by this waste, our leaders took steps to protect the Chesapeake, banning PCBs and setting stronger standards for sewage treatment plants, septic systems, and industrial sources. These steps have helped reduce pollution in the bay.

And yet Maryland has not seriously addressed another type of waste that is polluting and degrading the bay: chicken manure. Industrial-scale chicken production, particularly in Maryland's lower Eastern Shore, generates huge volumes of manure. Spread in excessive quantities on cropland as fertilizer, manure releases phosphorus that feeds unnatural algae blooms and triggers a chain of events that kills crabs, fish and other marine life critical to the bay's ecosystem.

This threat is no less severe than some of the other dangers Maryland has already more fully dealt with, but current standards to protect the bay from phosphorus pollution do not adequately address the problem of using land as a dumping ground for chicken manure.

It is time for Maryland to stop treating the bay as a dumping ground and to restore the Chesapeake to its valuable and respected role as a cornerstone of the state's economy, ecology and culture.

Phosphorus Pollution Damages the Chesapeake Bay

The Ecosystems of the Bay Are Struggling

As the nation's largest estuary, the Chesapeake Bay serves as a home for more than 3,600 species of plants and animals connected through complex ecosystems.[1] Yet decades of intensive agriculture and urban development on the shores of the bay have taken a toll, adding excessive nutrients and sediment that trigger massive algae blooms and annual dead zones, the decline of bay grasses, and the loss of fish, crabs and oysters in the bay.

Farmers, fisherman, scientists, boaters and the region's residents have long acknowledged the problems of the bay. Despite increased research about the bay, limits on fishing, changes to agricultural practices, and new development standards, water quality in the bay's tributaries and the bay itself has not significantly improved.

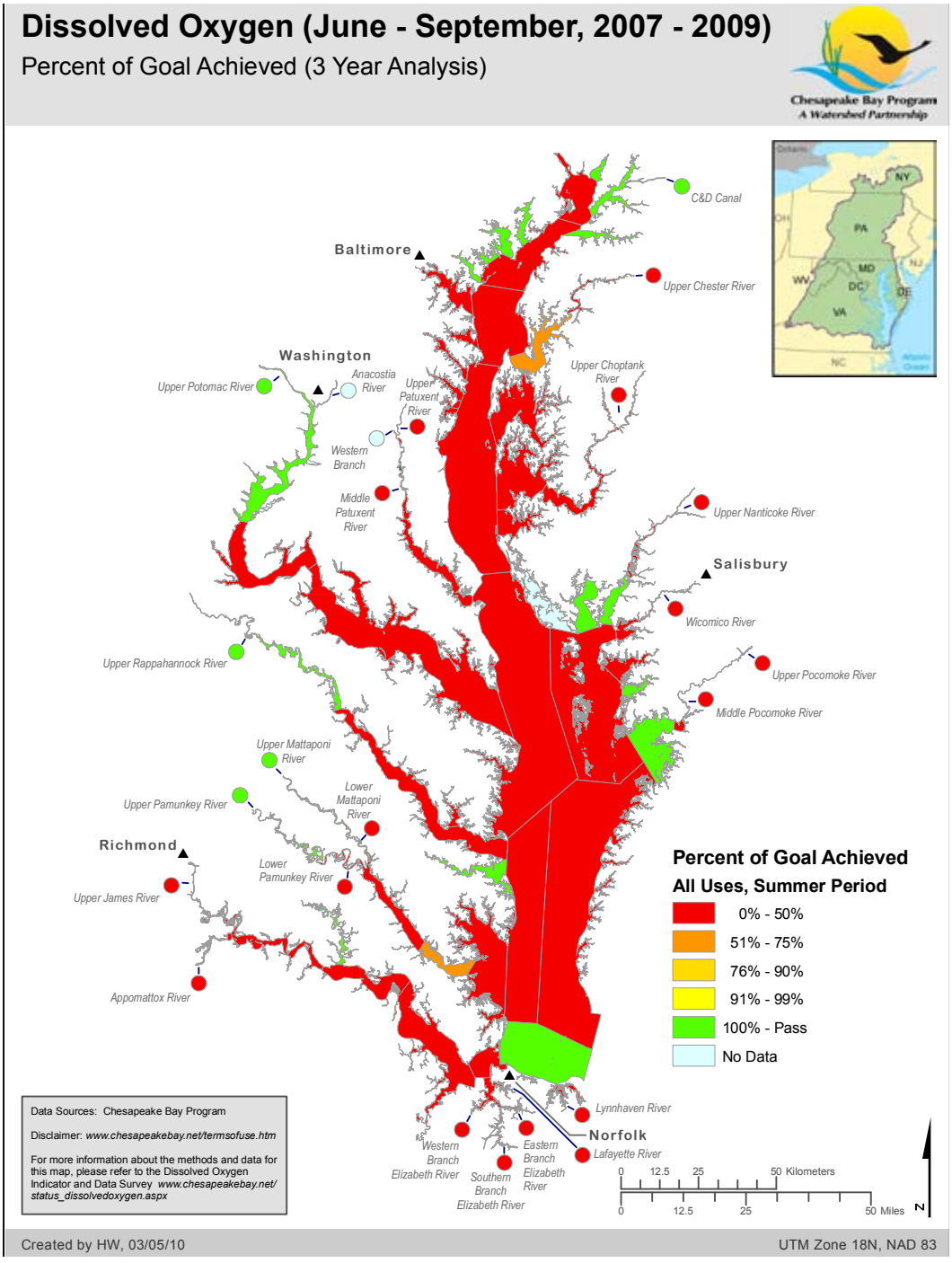
One of the most pervasive problems in the bay is excessive nutrient (nitrogen and phosphorus) and sediment pollution that causes growth of algae. Algae "blooms" flourish briefly on these nutrients and then die, consuming vast amounts of oxygen as they decay. As a result, levels of dissolved oxygen in the water drop below the concentration needed to support fish, crabs and oysters. Animals that can flee leave these areas of low dissolved oxygen; those who can't escape suffer through the stress of inadequate oxygen, making them more prone to disease. From 2007 to 2009, only 12 percent of the bay had sufficient levels of dissolved oxygen in the summer.[2] (See Figure 1.)

The most severely oxygen-depleted areas, where animals cannot survive at all, are known as dead zones. Data on the extent of low oxygen levels and of the dead zone are not yet available for summer 2011; researchers who study the bay predicted earlier in the year that the dead zone in 2011 would be one of the largest on record, covering more than one-third of the bay.[3]

In addition to consuming oxygen in the water, algae blooms block the sunlight that aquatic grasses need. Without sunlight, the grasses die, triggering other problems for the bay's ecosystem. Roots of these grasses are then no longer available to hold sediment in place, increasing the risk that oysters will be buried in silt. Blue crabs and fish such as menhaden, herring, shad,

and white perch lose places to shelter their young or hide. And the grasses are no longer available to replenish dissolved oxygen levels as they photosynthesize. In 2009, 86,000 acres in the bay were covered with grass, less than half the amount of grass needed for a healthy bay.[5]

Figure 1. Most of the Chesapeake Bay Fails to Meet Dissolved Oxygen Goals in the Summer[4]



Years of low dissolved oxygen levels in summertime, the loss of submerged aquatic vegetation, and overfishing have taken their toll on the bay's aquatic animals. Populations of rockfish, or striped bass, have dropped so much that Maryland and Virginia both imposed moratoriums on the fishery in the late 1980s. The moratoriums have since been lifted, but catch levels continue to be monitored closely. Oyster and soft shell clam populations have declined to tiny fractions of their historic levels, while the federal government officially declared the blue crab fishery a disaster in 2009, granting emergency aid to the industry.[6] These populations, already under severe pressure from overfishing, are further stressed by water pollution.

Phosphorus Pollution Comes from Activities in the Bay's Watershed

The key pollutants that trigger algae blooms and that have damaged the bay's ecosystems are phosphorus, nitrogen and sediment. Phosphorus and nitrogen foster normal plant and animal growth, but too much of these nutrients can cause the unnatural algae blooms that cause so much damage in the bay. Sediment carries phosphorus and smothers bottom-dwelling plants and animals. These pollutants are generated by activities within the bay's vast watershed.

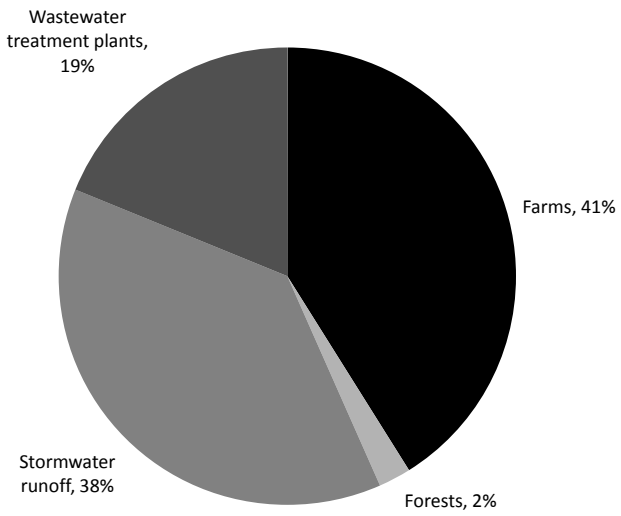
The Chesapeake Bay receives drainage from a 64,000-square mile watershed that encompasses parts of six states and Washington, D.C.[7] Farming and livestock production, urban and suburban development, wastewater treatment plants, septic systems, and other development and activities produce nitrogen and phosphorus that are then carried into the bay by approximately 100,000 rivers, creeks and streams.

Figure 2 shows that agricultural activities are the largest source of phosphorus pollution from Maryland, accounting for 41 percent of phosphorus pollution.[8] Regional data show that manure is responsible for a greater share of the pollution than chemical fertilizers.[9] Agriculture is also a major source of nitrogen to the bay, with more than one-third of the nitrogen flowing into the bay from Maryland coming from manure and chemical fertilizers used on agricultural land.

In addition to agriculture, water running off from urban and suburban roads, parking lots and rooftops contributes to pollution in the bay, as it picks up lawn fertilizer, pet waste and other contaminants that release large amounts of phosphorus and smaller amounts of nitrogen. Wastewater treatment plants contribute about 20 percent of Maryland's phosphorus and nitrogen pollution in the bay.

Addressing phosphorus pollution from agricultural activities, particularly manure-related pollution, is essential to improving the health of the bay.

Figure 2. Maryland Sources of Phosphorus Pollution in the Chesapeake Bay[10]



Poultry Production Is a Major Source of Phosphorus in the Bay

Manure is a valuable fertilizer because of the phosphorus and nitrogen that it contains. For that same reason, however, manure can also degrade water quality. Maryland's industrial scale chicken growing and processing industry generates millions of pounds of chicken litter annually, and still relies on application of manure to land as the primary means of disposal. The amount of phosphorus in that manure far exceeds what crops need and can absorb, with the result that excess phosphorus builds up in soil and ends up in the bay. Phosphorus is a particular concern due to the imbalance of nitrogen and phosphorus in chicken litter: when litter is applied to meet crop nitrogen needs, phosphorus is over-applied.

Chicken Production on the Eastern Shore

The Delmarva Peninsula, on the eastern shore of the Chesapeake Bay, is home to an extensive chicken growing and processing industry. Several large chicken producers—including Perdue (headquartered in Salisbury), Mountaire, and Tyson—have major operations in Maryland, Delaware and Virginia, with regional production of chickens totaling 786 million in 2010.[11] More than 70 percent of that production occurs on the Delmarva Peninsula.[12]

In Maryland alone, farmers had approximately 65 million broiler chickens on their farms at the end of 2007. Because farmers can raise and sell multiple flocks of chickens in the course of a year, broiler chicken sales in Maryland in 2007 reached 296 million.[13] Table 1 shows the county by county distribution of these flocks. Nationally, Maryland has one of the highest concentrations of chickens per acre of farmland.[14]

This intensive poultry production results in high volumes of manure. Chicken manure contains phosphorus, nitrogen and other chemicals, such as arsenic (which is sometimes added to chicken feed).[15] When manure is mixed with sawdust and other bedding material from chicken houses, it is referred to as "chicken litter." The broiler chickens raised on Maryland's Eastern Shore in 2007 generated approximately 550,000 tons of chicken litter.[16]

Table 1. Chicken and Manure Production by County, 2007[17]

Location	Chickens (millions)	Litter (tons/year)
Caroline	10.3	87,078
Dorchester	11.2	94,397
Kent	1.2	10,403
Queen Anne's	6.7	56,258
Somerset	12.1	101,734
Talbot	1.7	14,176
Wicomico	10.5	88,164
Worcester	11.7	98,457
All other counties	0.1	1,070
Statewide total	**65.5**	**551,737**

While dairy operations in the state also generate manure that is most easily disposed of by spreading on cropland, the number of dairy and beef cattle in the state is much smaller than the number of chickens. Farms in Maryland were home to 190,000 cattle in 2007—approximately equivalent in manure production to 38 million chickens—versus nearly 300 million chickens.[18]

The growers who feed and house tens of thousands of chickens at a time in large chicken houses must dispose of large volumes of chicken litter. Though large corporations that contract with growers to raise chickens control almost all elements of chicken production—setting standards for chicken houses, providing chicks and food to the growers, and collecting chickens to be taken to the slaughter house—those corporate entities leave responsibility for disposal of manure with the contract growers.

Because of its phosphorus and nitrogen content, chicken litter is useful as a fertilizer, whether spread directly on cropland or processed into dry pellets that are more easily transported and can be used in a variety of agricultural and horticultural applications. Most farmers prefer not to send chicken manure for processing into pellets and instead apply it to cropland as a cheaper source of nitrogen than chemical fertilizers. However, spreading large amounts of manure on cropland on the shores of the Chesapeake Bay creates multiple opportunities for manure to pollute the bay.

How Phosphorus in Manure Enters the Bay

The most obvious water pollution occurs when improper chicken litter spreading allows the litter to directly flow into waterways. During heavy rain or snowmelt, litter can pollute waterways if the waste has been applied too close to the edge of a field or on a field without an adequate vegetative buffer. Those waterways eventually drain to the bay, carrying with them the nutrients and bacteria from manure.

Even when litter is kept away from direct routes into waterways, the phosphorus in manure can enter the water. When phosphorus is present at low levels, it binds with soil particles. As that soil erodes, it can carry phosphorus along with it. If phosphorus levels in soil rise, not all the phosphorus is bound as tightly to soil. In soils where phosphorus is not trapped as tightly—also known as soil where the phosphorus saturation percentage is higher—rain and melting snow percolating through the soil can move phosphorus, eventually carrying it to drainage ditches, streams, rivers and the bay.

Widespread use of surface or subsurface drainage systems to help low-lying fields dry more quickly can increase nutrient pollution of waterways by giving nutrient-laced water an easy pathway from the field into nearby waterways. Anywhere from five to 13 percent of Maryland cropland has surface or subsurface drainage systems,

installed to speed draining of fields.[19] Drainage systems are widespread on the low-lying Eastern Shore.

As nutrient levels in soil rise, more phosphorus and nitrogen can move from fields into waterways. Phosphorus build-up in soil is an increasing problem in Maryland, particularly on agricultural land close to the bay.[20]

Phosphorus Saturation of Agricultural Land

The failure of chicken processing corporations to take responsibility for the waste produced by the chickens they own forces contract growers to dispose of that waste in ways that pollute water: applying it to cropland that already contains too much phosphorus. Since long before the development of chemical fertilizers, manure has been used to build soils and increase crop yields. Even with the advent of chemical fertilizer, manure retains an advantage as a cheaper alternative. However, application of such large volumes of manure as are produced on Maryland's Eastern Shore has created extensive elevated phosphorus saturation levels of soil due primarily to the imbalance of fertilizer nutrients in litter.

Manure contains both nitrogen and phosphorus. While these are essential nutrients for plant growth, above a certain level additional nutrients do not enhance plant growth and can pollute nearby waterways. The exact amount of each nutrient needed varies by crop. Corn grown for grain, for example, might require 160 pounds of nitrogen per acre and 60 pounds of phosphorus per acre for optimal growth and yield.[21] Spring-planted barley requires 65 pounds of nitrogen per acre and 50 pounds of phosphorus. If extra phosphorus is applied, the crop cannot use it; instead, the phosphorus remains in the soil.

On Maryland's Eastern Shore, farmers often apply excess amounts of phosphorus, for two reasons. First, the ratio of nitrogen to phosphorus in chicken manure doesn't align with the amounts needed by crops. A "typical" ton of chicken litter contains 73 pounds of nitrogen, 63 pounds of phosphorus, and 45 pounds of potassium.[22] A farmer who applies enough chicken litter to ensure optimal levels of nitrogen for a crop may end up applying nearly four times as much phosphorus as needed.[23] For example, applying enough chicken litter to meet the nitrogen needs of corn grown for grain results in over-application of 78 pounds of phosphorus per acre.[24] (Table 2 shows over-application rates for several different crops.)

Table 2. Crop Needs Versus Nutrient Content of Litter[25]

Crop	Yield target	Nitrogen needed (pounds/ acre)	Phosphorus needed (pounds/ acre)	Excess P, if litter is applied to meet N needs (pounds/ acre)
Corn for grain	160 bushels/acre	160	60	78
Corn for silage	25 tons/acre	180	130	25
Spring barley	80 bushels/acre	65	50	6
Tall fescue (initial planting)	3 tons/acre	150	50	79

The second, more significant reason for over-application of litter is that the region generates huge amounts of chicken manure and spreading it on fields is currently one of the few routes for disposing of it, since the companies making the bulk of the profits from chicken production are not adequately addressing their waste problem. Chicken production occurs in areas surrounded by cropland on which chicken growers or other farmers raise corn, soybeans or other crops. Applying chicken manure to their own land or selling manure to neighboring farms is the cheapest and easiest way for chicken growers to dispose of excess manure.

Chicken production on Maryland's Eastern Shore generates far more phosphorus in chicken litter than crops in the area can use. Poultry litter produced in Caroline County contains four times more phosphorus than crops in the county can use. Manure produced in Somerset County contains 8 times more than crops in that county need, and in Wicomico and Worcester counties, the ratios are 4.5 and 6.5, respectively.[26] This equals 300,300 tons of excess poultry litter in just four counties. (See Table 3.)

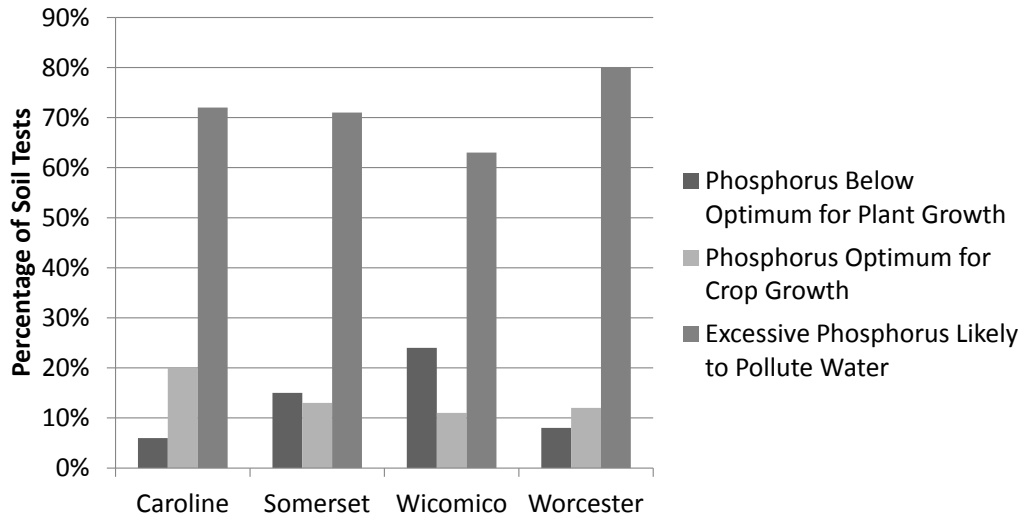
Table 3. Amount of Poultry Litter that Exceeds the Phosphorus Needs of Crops[27]

County	Excess Poultry Litter (tons)
Caroline	60,500
Somerset	73,600
Wicomico	87,900
Worcester	78,300
Total	**300,300**

Note: Excess poultry litter is calculated assuming dairy manure and non-meat poultry litter generated in the state is applied to cropland first, because those types of manure are harder to store and transport than broiler litter.

The excessive application of manure has caused phosphorus levels to rise in soil where manure has been applied as fertilizer year after year. Crops need a limited amount of phosphorus. Fertilizer or manure applications that increase phosphorus above

Figure 3. Phosphorus Soil Test Results for Four Maryland Counties in 2002[30]



a certain level are unlikely to increase crop yields (except to the extent they add needed nitrogen) and merely add to the total load of phosphorus in the field. When soil phosphorus saturation crosses a threshold of roughly 25 percent, the rate at which phosphorus dissolves in water increases rapidly.[28]

Much agricultural land on Maryland's Eastern Shore has a high soil phosphorus saturation level, containing far more phosphorus than crops need. Soil test data from the University of Maryland's Soil Testing Laboratory in 2002 show that more than 60 percent of soil samples from four Maryland counties—where tens of millions of chickens are raised annually—have a soil phosphorus saturation of 18 percent or greater.[29] (See Figure 3.) More recent data from the lab are not available because it closed in 2003.

Two different calculation methods "both indicate an overwhelming surplus of [phosphorus] from manure and fertilizer in all of the counties evaluated."

– from a report on Mid-Atlantic phosphorus surpluses co-authored by Tom Simpson, former chair of the Chesapeake Bay Program's Nutrient Subcommittee

Current Policies to Limit Phosphorus Pollution Are Inadequate

From the 1950s through the 1980s, researchers believed that as long as soil didn't erode, phosphorus that had been added to a field as fertilizer or manure remained in place. Scientists had little understanding of how phosphorus could dissolve in water and be transported by rain or melting snow into groundwater or surface waters. Researchers now know that if phosphorus levels rise significantly above the amount needed by crops, the phosphorus can move with runoff from the soil. Unfortunately, the state's standards that guide manure application on fields do not sufficiently take this into account. The standards fail to recognize all the ways that phosphorus can enter water and therefore do not adequately protect the health of the bay.

While the most protective strategy would be to limit manure application to those fields where crops need additional phosphorus, Maryland's policy is far weaker. It not only allows manure application in excess of the amount of phosphorus that crops need, but also allows application on fields that are highly saturated with phosphorus and where additional phosphorus may be lost to waterways.

Furthermore, by allowing farmers to spread more phosphorus on land than crops will remove, the rules allow phosphorus levels to build up over time, increasing the odds that phosphorus from those fields may pollute water in years to come. The current rules do nothing to encourage a long-term balance in the supply of and demand for phosphorus in the region—the key step that must be taken to protect the Chesapeake Bay from phosphorus pollution over the long haul.

Maryland's Current Phosphorus Management Guidelines

Maryland adopted its current standards to control agricultural pollution with the Water Quality Improvement Act of 1998. Farmers must submit nutrient management plans to the Maryland Department of Agriculture (MDA), specifying how much phosphorus and nitrogen will be applied for each crop grown on their land.

The detailed and technical plans must be developed by a certified consultant.[31]

Under the rules implementing the law since 2004, Maryland has required farmers to periodically test soils for phosphorus levels. (See Table 4 for an explanation of key phosphorus thresholds.) If soil tests show that phosphorus levels are already far above the level needed for optimal crop growth, then the farmer must consider how site characteristics and management strategies will influence phosphorus loss.[32] This calculation of the risk that phosphorus will migrate into waterways from a particular field is known as the phosphorus site index (P-index). The site characteristics that the P-index draws upon include erosion rates, surface runoff, subsurface drainage, leaching potential, and the field's proximity to surface water. Relevant management strategies include the results of soil tests for phosphorus, what fertilizers will be used, and how much fertilizer will be applied and by what method.

The combination of these factors in the P-index model produces a number that is supposed to indicate the relative risk that phosphorus applied to a particular field will end up in waterways. The field is then assigned a low, medium, high or very high risk of phosphorus loss. If the P-index produces results that suggest a high risk of phosphorus loss from the field, then the farmer must limit phosphorus application to the amount that the crop is expected to remove that year. If the P-index estimates that phosphorus loss will be very high, then no more phosphorus can be applied to that land until the loss risk drops.[34] The risk can be lowered through changes in management practices such as using cover crops, changing crop rotation patterns, or planting vegetated buffer strips.

On soils that have elevated levels of phosphorus but not so much phosphorus that a P-index value must be calculated, farmers may use a nitrogen-based management strategy.[35]

Several Authorities Agree that Maryland's Current Approach Is Flawed

Leading regulatory and research authorities agree that the principles underlying Maryland's phosphorus management requirements have multiple shortcomings that fail to protect the Chesapeake Bay. Primarily, the P-index allows excess manure to be applied on fields already overloaded

Table 4. Key Phosphorus Thresholds[33]

Description of Phosphorus Level	Relative Nutrient Availability (fertility index value)
Phosphorus "low" relative to crop needs	0-25
Phosphorus "medium" relative to crop needs	26-50
Optimal phosphorus level for crop growth	51-100
Point at which phosphorus exceeds all possible crop needs	101
Threshold at which P-index must be used	150

Note: The Fertility Index Value (FIV) is a calculated value that allows for easier comparison of phosphorus test results from different soil labs, and therefore is the measure that the P-index is linked with.

with phosphorus, exacerbating Maryland's long term problem of phosphorus-laden farmland.

A key piece of evidence is that phosphorus pollution of water is on the rise in some agriculturally dominated watersheds, despite the adoption of new standards nearly 10 years ago to guide manure application in situations when soil phosphorus levels already are high. A recent analysis by the U.S. Geological Survey of pollution trends in the Choptank River, which drains parts of Caroline, Dorchester, Queen Anne's and Talbot counties, shows that phosphorus levels have risen by an average of 1.9 percent per year from 2000 to 2008.[36] These four counties are home to nearly half of Maryland's chicken population and relatively few residential communities.[37]

U.S. EPA Rejects Use of the Current P-index

The U.S. Environmental Protection Agency (EPA) has concluded that the P-index is not a suitable tool to guide phosphorus application to federally managed land.

After studying the shortcomings of the P-index as used in Maryland and other states in the Chesapeake Bay region, the EPA has changed its management strategy for federally managed land in the Mid-Atlantic. In a guidance document to managers of federal property in the Chesapeake Bay watershed, the EPA wrote: "EPA believes that the P-index at this time is significantly flawed and that its use in many cases is likely to result in significant over-applications of P to cropland and result in P-laden runoff to the Chesapeake Bay." Without revisions to the P-index, the agency continued, "EPA believes that it would be inappropriate to base its recommendations for protection of the Chesapeake Bay on the P-index approach."[38]

The problem is that, despite the elaborate calculations of the P-index, manure applied in compliance with the P-index can result in additional phosphorus loads in waterways. Researchers have measured significant phosphorus runoff from fields with medium risk ratings from the P-index.[39] A major reason for this is that the current P-index does not adequately incorporate movement of phosphorus in subsurface water.

In place of the P-index, the EPA has adopted a recommendation that no phosphorus be applied to soils with a phosphorus saturation of 20 percent or greater.

The Designers of Maryland's P-index Acknowledge Its Limitations

The P-index is a national tool created to be tailored to local conditions. In Maryland, researchers at the University of Maryland adapted the P-index to be used for the soils and topography common in the state. Those researchers have been evaluating the performance of the P-index, and have discovered that the current P-index underestimates the potential for phosphorus movement into streams and the bay. In addition, research conducted during the initial development of the P-index suggests that phosphorus can leach from some fields that appear to be low risk.

Underestimating Phosphorus Movement

Phosphorus can be transported from a field through three pathways, and the risk of that transport increases when too much phosphorus-laden manure is applied to fields. Phosphorus can bind with soil and be carried off a field with eroding soil; it can dissolve in surface water and wash off the field; or it can dissolve in groundwater and leach out through subsurface pathways. Though subsurface movement of phosphorus is widespread on the Eastern Shore, the current P-index greatly underestimates that transport potential.[40]

A 2007 study conducted in Somerset

County revealed that huge volumes of phosphorus can escape from land that has been treated with poultry litter for more than two decades and that is now saturated with phosphorus. Researchers measured phosphorus in soil and in runoff from a research farm owned by the University of Maryland Eastern Shore.[41] The farm was a commercial broiler facility until 1997 with three broiler houses and a covered litter storage space. Soil phosphorus levels were more than twice the P-index triggering threshold.

The research fields, like many on Maryland's Eastern Shore, have an extensive system of drainage ditches carrying water into nearby rivers. That water carries heavy loads of phosphorus. Water in the seven ditches that drained the study area contained 26 to 309 times more phosphorus than the lowest level at which excess nutrients cause water pollution and deplete dissolved oxygen.[42]

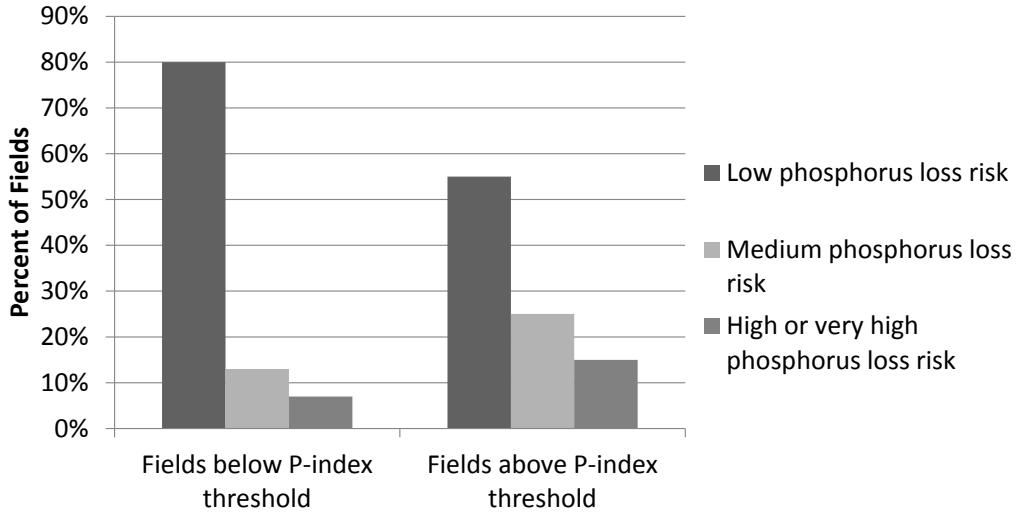
The developers of the P-index now recognize that 90 percent of the phosphorus in drainage ditches comes from subsurface runoff and that the risk ratings produced by the index should be responsive to this.[43] The current P-index is not very sensitive to this source of phosphorus. A field with a high risk of subsurface phosphorus transport will not necessarily earn a high-risk result from the P-index. As a result, farmers are allowed to apply manure to fields that have a high risk of releasing the newly added phosphorus into the bay.

A revised P-index is in development that may help address this shortcoming.

Ignoring the Problem Created by Fields Below the P-Index Threshold

Another problem with Maryland's current phosphorus management rules is that fields with phosphorus levels below the P-index threshold—fields which are therefore presumed to be safe for the application of manure—can also be a source of pollution. If a simple soil test reveals that phosphorus levels are below a threshold level (see Table 4 on p. 14), the farmer is not required to calculate a P-index value for the land before spreading manure, even if the phosphorus level is still well above that needed to sustain crops. Some of these

Figure 4. Fields with Moderate Phosphorus Levels Can Present a High Risk of Pollution[45]



fields, however, still pose a risk of releasing significant amounts of phosphorus into nearby waterways.

Scientists who helped develop the P-index for use in Maryland calculated P-index scores for sample fields across the state. They included a total of 646 fields with soil phosphorus levels both below and above the P-index threshold. For fields above the threshold, 21 percent (61 fields) had a high or very high phosphorus loss risk as calculated by the P-index. However, a number of fields with phosphorus levels below the P-index threshold still had a high or very

Do Farmers Comply with Nutrient Management Guidelines?

Maryland's poorly designed P-index may not be the only reason why phosphorus continues to move from agricultural land into the Chesapeake Bay. Lack of compliance with nutrient management guidelines may be another cause of the problem. Because clear data are not available on how closely farmers adhere to the guidelines, however, it is impossible to assess the scope of this problem. Different data sources suggest different levels of compliance.

A U.S. Department of Agriculture survey showed that farmers in the Chesapeake Bay region followed good management practices on just 17 percent of cropland to which phosphorus was applied from 2003 to 2006.[46] The USDA defined good management according to the rate, timing and method by which fertilizer or manure was applied. (The USDA did not rely on soil phosphorus tests to determine if farmers were using good management practices.)

Within Maryland, data from the Maryland Department of Agriculture suggest somewhat better performance, at least in terms of submitting required paperwork. Of the nearly 6,000 farms for which nutrient management plans need to be submitted, MDA had received documents for 99.8 percent by the end of 2009.[47] However, MDA did not provide any assessment of the quality of the plans included in those documents or how well farmers implemented their plans. Farmers also need to provide annual reports to MDA demonstrating compliance with their nutrient management plans. As of the end of 2009, MDA had received 99 percent of the expected annual reports. As with the nutrient management plans, there are no data on the quality of those reports.

The results of farm inspections suggest that plans may be out of date or ignored. MDA performed 400 in-person inspections of farms in 2009 to verify that farmers' records and receipts matched what they had promised to do in their nutrient management plans.[48] Of the inspected farms, 25 percent had out-of-date plans and another six percent of farmers refused to allow the inspection or had such disorganized and incomplete records that an inspection wasn't possible.

A more precise assessment of compliance with nutrient management requirements is not possible because of the lack of data. Nutrient management plans, annual implementation reports, and soil test results are not available for public inspection. As a result, there is little data available on whether farmers have implemented agricultural practices that comply with the letter and the spirit of the law.

high risk of creating phosphorus pollution. The researchers calculated that 7 percent (25 fields) of those that are considered to be lower phosphorus fields according to the current P-index had a high or very high runoff risk.[44]

As a result, even farmers who apply manure guided by soil test results and in compliance with nutrient management plans may be adding phosphorus to cropland that will end up polluting the bay.

The Creators of the National P-index Model Recognize It Does Not Provide a Long-Term Solution

In the early 1990s, the U.S. Department of Agriculture created SERA-17, a group of research scientists, policy makers and educators from various public and private institutions. The purpose of the group is to review options for minimizing phosphorus pollution of waterways from agricultural activities. A recent SERA-17 paper emphasizes that the P-index is not a long-term solution for the problem of preventing excessive manure application from damaging water quality.

The P-index is designed to identify which fields that are already highly saturated with phosphorus are the least likely to release phosphorus when additional manure is applied; it is not designed to ensure that soil phosphorus saturation drops to safe levels. The SERA-17 scientists acknowledge that shuffling manure from high-risk locations to low-risk locations is a short-term solution and that "for long-term sustainability, applications of [phosphorus] must approach a balance with crop removal."[49]

Maryland is not close to that balance. Chicken growers in the state generate more phosphorus in manure than needed by crops in Maryland. As a result, excess manure applied to fields causes phosphorus saturation levels in soil to rise, increasing the acreage that may release phosphorus into the bay. For the long-term health of the Chesapeake Bay, phosphorus levels in soil need to return to the point where phosphorus will not escape from fields.

The researchers continue their warning about the limitations of the P-index by saying that "in areas of intensive animal production, the long term goal must be to match manure [phosphorus] production with local crop [phosphorus] requirements, or to find alternative uses for the manures outside the farm boundary."[50] This is the challenge that Maryland must address.

Policy Recommendations

Industrial chicken production in Maryland and surrounding states has taken a toll on the health of the Chesapeake Bay. The millions of pounds of chicken litter produced by this industry add significant amounts of phosphorus pollution to the streams and rivers that end up in the bay. Solving the problem of phosphorus pollution from manure in the Chesapeake Bay will require multiple changes within Maryland and the bay's watershed.

First, Maryland should end applications of chicken litter that are likely to pollute the bay. The P-index does not adequately protect against over-application of manure and phosphorus that pollutes the bay. By design, it is intended for use when phosphorus saturation levels are already too high and to avoid fertilizer application only on land with the highest relative risk of polluting streams and the bay. In the decade-plus that the P-index has been in use, phosphorus levels in bay tributaries have continued to rise.[51]

Maryland should adopt a more protective standard that would prohibit spreading manure on soils that already contain enough phosphorus for crop needs. Maryland policy makers should take the following steps to phase in such a standard:

- First, lower the phosphorus threshold that determines when farmers should use the P-index. Significant nutrient loss can occur when manure is applied to soils where phosphorus levels are below the current P-index threshold but still above the level needed by crops. At the same time, the state should prohibit application of phosphorus to soils with a phosphorus saturation of 25 percent or greater, eliminating manure application on soils most over-loaded with phosphorus.

- For the next phase, the phosphorus saturation percentage above which manure application is prohibited should be lowered. Maryland should prohibit application of phosphorus to soils with a phosphorus saturation of 20 percent or greater. This is the standard that EPA has adopted for management of federal lands in the bay watershed. At the same time, it is possible that the state's revised P-index in

development may better account for subsurface phosphorus movement.

These steps should help Maryland reach the point where it can *prohibit manure application on fields where phosphorus soil tests show levels above agronomic need*.

To ensure that farmers are complying with these new standards, more information needs to be available on compliance. Data on soil test results need to be made available to those who monitor water quality plans and to the public to ensure that there is genuine progress toward reducing the flow of nutrients into the bay.

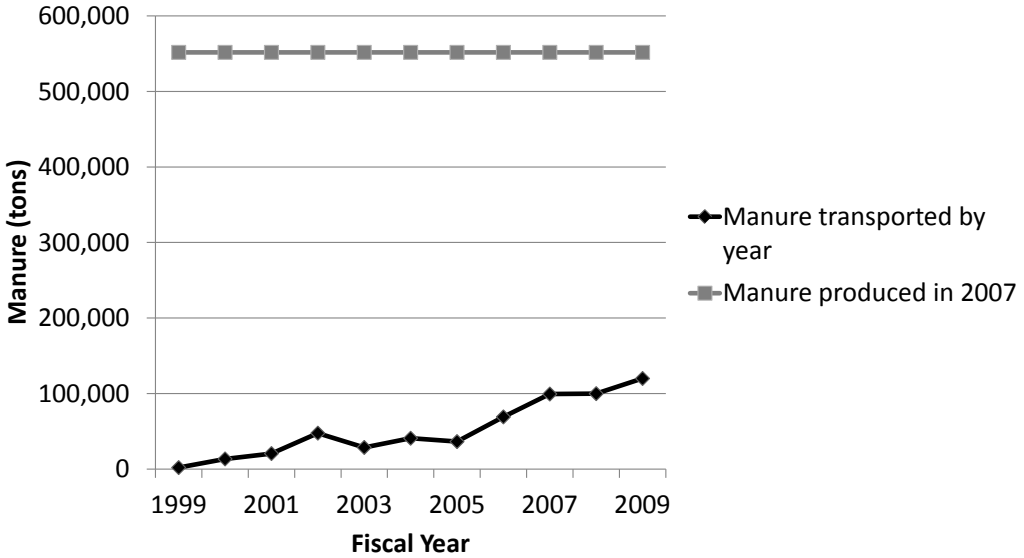
Second, the volume of phosphorus in manure that needs to be disposed of through land application must be brought into balance with the amount of nutrients that crops need. So long as manure applied to fields contains more phosphorus than crops can remove, phosphorus levels in soil will continue to rise, adding to the bay's pollution problems.

One alternative to spreading manure on farmland is to process more manure into fertilizer pellets that are easier to transport out of the region. Currently, Perdue's AgriRecycle facility dries and processes chicken litter into pelletized organic fertilizer. The company pays to truck manure from farms to its Sussex County, Delaware, facility. Perdue estimates that half of the pelletized fertilizer is sold to areas outside the Chesapeake Bay watershed, thereby lessening nutrient pollution risks for the bay.[52]

Perdue's AgriRecycle facility has processed 750,000 tons of poultry litter in the past decade.[53] That's just a fraction of the total manure produced on the Delmarva Peninsula in that time. As land application of manure is restricted to limit phosphorus pollution, demand for pelletizing may increase. Increasing the plant's capacity could reduce the amount of manure farmers need to spread on their fields and potentially move the manure out of the bay watershed.

Expanding the Maryland Department of Agriculture's Manure Transport Program also would help to move chicken manure away from the most phosphorus-laden soils.

Figure 5. Manure Moved Through the Manure Transport Program Versus Total Chicken Litter Production[55]



The transport program moves thousands of tons of manure out of high impact areas to farmland with lower soil phosphorus saturation levels.[54] (See Figure 5.) The program moves only a fraction of the total amount of manure produced.

In 2009, the program moved more than 5,000 tons of manure out of Caroline County, equal to four percent of the excess manure in the county that wasn't needed for optimal crop growth.[56] The program moved a higher percentage of manure in Somerset, Wicomico and Worcester counties (19, 26 and 18 percent, respectively). However, the remaining volume of excess manure in those counties was many times what local crops needed. The Manure Transport Program does not necessarily move nutrients out of the bay watershed, but it can move manure to areas where it is less likely to affect the bay. Expanding the transport program, with funding from industrial agriculture companies, would help ease the transition toward a tighter standard governing manure application.

Any alternative plan for disposing of chicken manure should require vertically integrated poultry producers such as Perdue, Tyson and Mountaire to take responsibility for the pollution that their activities produce. Perdue, for example, provides chickens and feed to growers who raise the birds in buildings constructed to Perdue's standards.[57] Veterinary care and oversight is provided by Perdue staff. Perdue workers collect the birds for slaughter in Perdue-owned facilities.

The only part of the process for which Perdue claims little control or responsibility is dealing with the litter in chicken houses. That is left to Perdue's 2,200 individual contract growers.[58] Meanwhile, Perdue has annual sales of $4.6 billion that make it the third largest producer of chickens in the nation.[59] Companies like Perdue have the resources to help deal with the problem of excess manure and nutrients that pollute the bay, and they should be required to play a lead role in addressing this pollution problem and financing solutions to it.

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