Center For
Agricultural & Natural
Resource Policy

POLICY ANALYSIS REPORT

UNIVERSITY OF MARYLAND

Best Management Practice Use and Nutrient Management in Maryland:

A 2010 SNAPSHOT

Erik Lichtenberg | Doug Parker | Sarah Lane

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Contents

Acknowledgements

This report was prepared by the University of Maryland under award number NA09NOS4190170 from the Office of Ocean and Coastal Resource Management (OCRM), National Oceanic and Atmospheric Administration (NOAA), through the Maryland Department of Natural Resources Chesapeake and Coastal Program. The statements, findings, conclusions and recommendations are those of the authors and do not necessarily reflect the views of NOAA or the US Department of Commerce. We thank Royden Powell, Louise Lawrence, John Rhoderick and Beth Horsey of the Maryland Department of Agriculture, Barbara Rater of the National Agricultural Statistics Service, US Department of Agriculture, Dana York of Green Earth Connection and Bob Ensor of the Howard County Soil Conservation District for their comments and suggestions. Responsibility for the contents of this report is the authors' alone.

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COVER PHOTOS: CONTOUR FARMING - EARL D. WALKER/SHUTTERSTOCK.COM, CORN STALK - EDWIN REMSBERG

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Introduction

Tighter regulations to meet the Chesapeake Bay Total Maximum Daily Load (TMDL) limits will result in increased demand for conservation implementation in nonpoint sectors including agriculture. Water quality goals set by the TMDL will be achieved through implementation of best management practices (BMPs) for conservation and nutrient management. TMDL regulations will also require Maryland to provide reasonable assurance of implementation by demonstrating that load reductions can be achieved with the resources and strategies Maryland has dedicated to the TMDL goals.

Maryland's Watershed Implementation Plan (the Plan) provides a roadmap for TMDL compliance. One way the Plan provides reasonable assurance is by identifying commitments and strategies for BMP implementation that will achieve the TMDL targets. The BMPs selected in the Plan include a timeline for implementation, units of implementation, estimated implementation costs, available funding programs and an associated nutrient reduction. The second way the Plan provides reasonable assurance is with a catalogue of alternative strategies, known as contingencies, for slow or incomplete implementation. Contingency implementation will be needed if any strategy is falling behind its implementation schedule.

For agriculture these BMPs include traditionally implemented practices and new innovative practices and technologies for reducing nutrient and sediment loads. These practices and technologies are divided into those that (a) reduce loads from the land, (b) manage nutrients in manure, and (c) improve nutrient application rate, timing and methods to maximize crop uptake and minimize nutrient runoff. These BMPs are implemented through a combination of cost-share programs, and regulatory requirements for nutrient management and animal feeding operations.

Maryland's Watershed Implementation Plan includes many strategies and contingencies that were included in a survey conducted by the University of Maryland (UMD) in the spring of 2010. This survey collected information from Maryland agricultural producers regarding farm characteristics, BMP activity, and nutrient management planning. The United States Department of Agriculture National Agricultural Statistical Service (NASS) carried out the survey sampling and collection of responses.

KEY POINTS

- The use of most best management practices is more common in large operations than small ones.
- Large operations tend to use a larger number of best management practices than small ones.
- Most best management practice adoption is self-financed.
- Receipt of cost sharing is more common in large operations using a larger number of best management practices.
- Over a third of Maryland farm operations report not having nutrient management plans.
- Compliance with Maryland's nutrient management planning requirements is extremely high at large operations and quite low at small operations.
- There is significant room for expanded use of best management practices—and cost sharing—especially among smaller operations. Further study is needed to determine whether targeting small operations is cost effective, however: There has been no documentation of the relative contributions of small and large operations to nutrient runoff and erosion and thus to Bay water quality.

This report summarizes information obtained from that survey about current usage of conservation and nutrient management BMPs and about the role cost-sharing has played in BMP implementation to date. That information should help Maryland refine existing programs and determine if new programs are needed to meet TMDL goals. It provides a snapshot of how commercial farm operations in the state of Maryland are incorporating BMPs and how they are designing and implementing nutrient management plans. The information should help Maryland determine what is being implemented and who is implementing it. Understanding how current cost-share programs are working should help determine if the programs are worth pursuing further and whether other programs should be structured similarly. Trends in the utilization of existing cost-share programs will highlight if the BMPs are being implemented because of cost-share assistance or if implementation is occurring without that assistance. If a BMP is heavily implemented without cost-share dollars, it may be advantageous to use that money towards a lesser-used practice to incentivize its implementation. Results from the survey may also direct the structure of new programs to accelerate BMP implementation and meet TMDL goals.

Data

In the spring of 2010, UMD commissioned a survey to collect information from Maryland commercial agricultural producers regarding BMP activity and nutrient management planning. The US Department of Agriculture's National Agricultural Statistical Service (NASS) carried out the sampling and collection of responses. NASS mailed surveys to 1,000 farm operations in the State of Maryland selected to give an accurate representation of farm operations. The NASS definition of a farm is any operation from which $1,000 or more of agricultural products were, or normally would be, produced and sold during the census year. A stratified sampling design was used to ensure sufficient sampling of high revenue farm operations that account for the bulk of farming activity in the state. Farmers selected for the sample were pre-notified by letter. The survey was administered initially by mail with mail follow-up. Subsequent follow-up was collected by telephone. NASS obtained responses from 523 farm operations. The responses were combined with a revenue-based expansion factor provided by NASS to create a weighted sample that accurately reflects commercial farming in the state of Maryland.

The survey collected information on acreage ownership, type of crop planted, the number and type of animals present, and farm sales during 2009. The survey asked for geographic characteristics related to the slope of the land and proximity to water bodies located on or immediately adjacent to the farm. Information on BMP implementation included whether each of 13 different classes of BMPs was used, treated acreage if used and whether cost-sharing had been received for each type of practice. Respondents were asked if they had a nutrient management plan and, if so, who prepared the plan, whether the plan targeted nitrogen or phosphorus, nutrient management conservation practices used, and whether cost sharing had been received for those practices.

Best Management Practices

Prevalence of Best Management Practice Usage

As noted above, BMP implementation is the primary mechanism envisaged for achieving TMDL allocations and WIP compliance. Table 1 reports the prevalence with which farmers in our sample report using the main classes of BMPs, adjusted for the applicability of each class to the farm operation. The full weighted sample was used for vegetative cover and water conveyance and storage, which are applicable to all farms in the sample. Cover crop, conservation tillage or no till, contour farming, strip farming and retirement of highly erodible land are applicable to farms with crop operations; the prevalence of these practices was estimated for the 88 percent of the weighted sample reporting a positive amount of crop acreage. Riparian buffers, stream fencing, and wetland restoration are applicable to the 72 percent farms in the sample with a water body on or adjacent to them. Waste storage structures are applicable to the 62 percent of farms reporting some livestock[4] while heavy use poultry area concrete pads are applicable to the 2 percent of farms reporting poultry.

Table 1 also reports on farmers' use of cost sharing in BMP implementation. Maryland leverages a variety of revenue streams to fund agricultural BMP implementation. The Maryland Agricultural Water Quality Cost-Share (MACS) Program assists farm operations

[4] We do not differentiate commercial scale livestock production from farms with few livestock. Therefore, our figures likely underestimate adoption of water storage structures and lagoons by commercial livestock producers.

Table 1

BMP Use and Cost Sharing Participation

TYPE OF PRACTICE	PERCENTAGE USING	NOT RECEIVING COST-SHARE	RECEIVING COST-SHARE	RATIO NOT RECEIVING TO RECEIVING COST-SHARE
All Farms (100% of total)				
VEGETATIVE COVER	21.0%	17.0%	4.0%	4.3 : 1
WATER CONVEYANCE AND STORAGE	19.5%	12.3%	7.2%	1.7 : 1
Farms with Crop Operations (88% of total)				
COVER CROP	23.9%	12.0%	11.9%	1 : 1
CONSERVATION/NO TILL	41.8%	38.0%	3.8%	10 : 1
CONTOUR FARMING	9.4%	8.7%	0.7%	12.8 : 1
STRIP FARMING	12.9%	12.4%	0.5%	25.5 : 1
RETIREMENT OF HIGHLY ERODIBLE LAND	6.8%	5.8%	1.0%	5.5 : 1
Farms with Water Body Located on or Immediately Adjacent (72% of total)				
RIPARIAN BUFFER (FOREST OR GRASS)	32.7%	22.4%	10.3%	2.2 : 1
Farms with Wetland Located on or Immediately Adjacent (22% of total)				
WETLAND RESTORATION	6.7%	3.7%	3.0%	1.2 : 1
Farms with Streams Located on or Immediately Adjacent and Livestock or Poultry Operations (40% of total)				
STREAM FENCING, STREAM CROSSING, OR WATER TROUGHS	33.7%	19.4%	14.3%	1.4 : 1
Farms with Livestock or Poultry Operations (62% of total)				
POULTRY MANURE OR LIVESTOCK WASTE STORAGE STRUCTURE OR LAGOON	18.9%	9.4%	9.5%	1 : 1
Farms with Poultry Operations (2% of total)				
HEAVY USE POULTRY AREA CONCRETE PADS	37.0%	18.9%	18.0%	1 : 1

PHOTO: CHESAPEAKE BAY PROGRAM/WWW.CHESAPEAKEBAY.NET

Riparian buffers protect streams by filtering sediment and utilizing nutrients before they reach the water.

in establishing BMPs by providing funds to help offset the costs incurred. MACS provides farmers with grants to cover up to 87.5 percent of the cost to install BMPs on farms that control soil erosion, manage nutrients, and safeguard water quality. Many of Maryland's implementation strategies are appropriated to the MACS Program. For example, the 2011-2012 Cover Crop Program is administered by the MACS Program and funded by the Bay Restoration Fund and the Chesapeake and Atlantic Coastal Bays Trust Fund. Cost-share support for the Manure Transport Program and Soil Conservation and Water Quality Plan Program are also administered through MACS.

In addition to MACS, Maryland uses the USDA Environmental Quality Incentives Program (EQIP) to provide financial assistance of up to 75 percent for the installation of BMPs. The program is administered by NRCS through local soil conservation districts and projects may be co-cost-shared with the MACS Program. MACS or EQIP can also cost-share for private sector development of nutrient management plans. Federal programs in which Maryland also participates include the Wetland Reserve Program (WRP) and Conservation Stewardship Program (CSP), both administered by NRCS, and USDA's Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP).

The information in Table 1 indicates that most BMPs are used by relatively small shares of commercial farm operations. Apart from conservation/no till, heavy use concrete pads, stream fencing and riparian buffers less than a third of our sample use any of these conservation practices—and each of these practices are used by roughly a third of our sample.

Usage of cost-sharing is relatively low. BMPs most likely to have received cost-sharing support include cover crops, poultry manure/livestock waste storage structures, and heavy use poultry area

PHOTO: CHESAPEAKE BAY PROGRAM/WWW.CHESAPEAKEBAY.NET

No till corn. Leaving stubble on the field reduces erosion and nutrient runoff.

Figure 1

Adoption of Water Conveyance Structures and Vegetative Cover by Farm Size

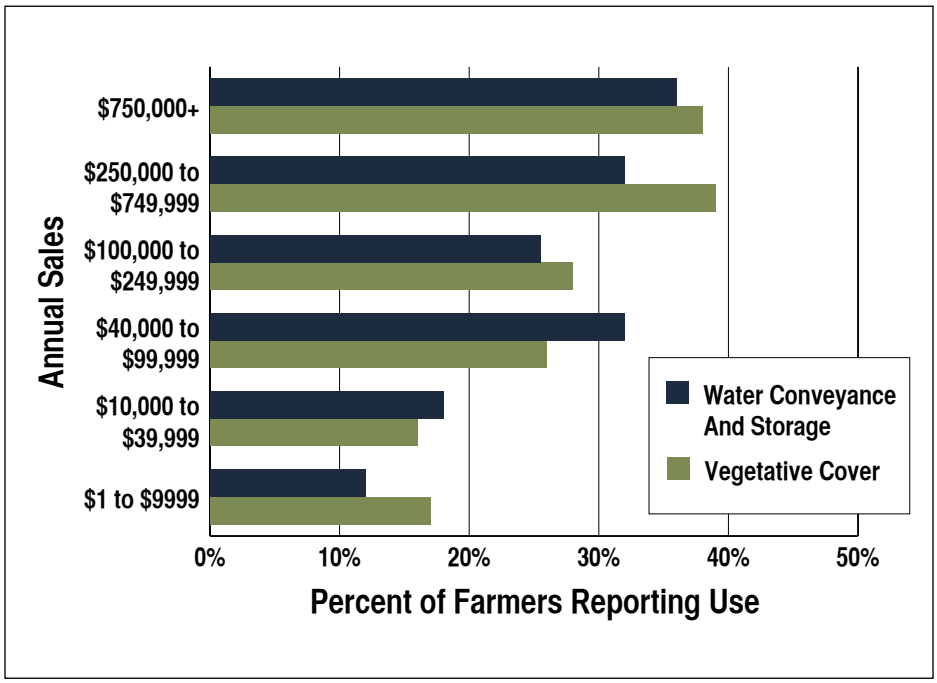
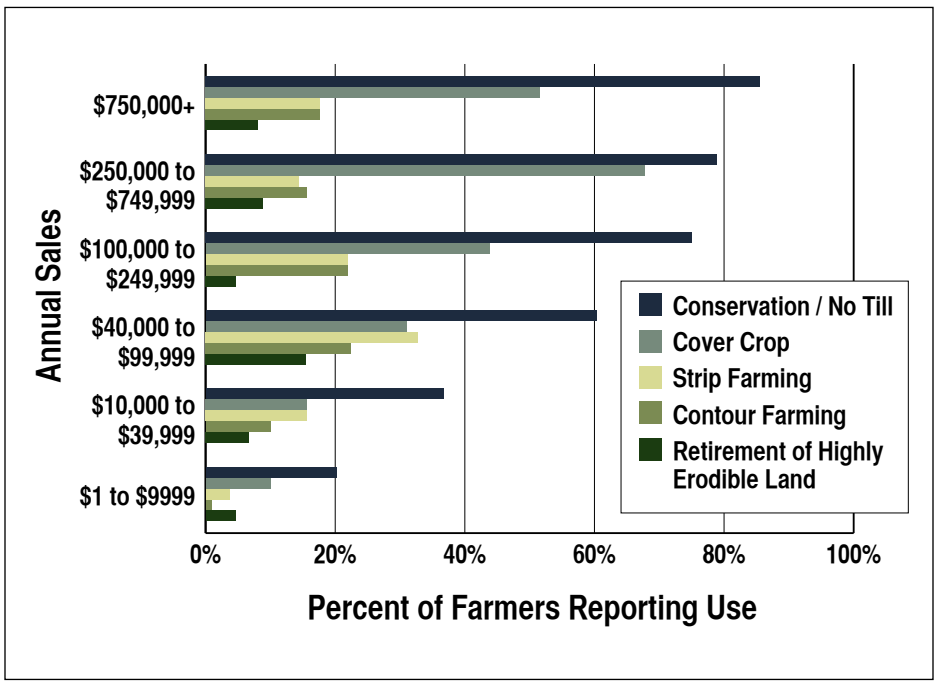


Figure 2

Adoption of Crop BMPs by Farms with Crop Operations by Farm Size



concrete pads. About half of these BMPs received some cost sharing. About 40 percent of farmers implementing wetlands restoration or installing stream fencing reported having received cost share funds. Percentages of farmers receiving cost sharing for other BMPs was substantially lower. For three BMPs, conservation/no till, contour farming, and strip farming, farmers self-finance 10 times more often than using cost-share. Overall, our data indicate that most BMP adoption is self-funded.

BMP Adoption by Farm Size

A breakdown of adoption rates by farm size indicates that the greatest potential for increased adoption generally lies with smaller operations: Prevalence of BMP use is substantially greater among larger operations than small ones. Roughly 35-45% of operations with annual sales greater than $250,000 have vegetative cover and use water conveyance and storage structures, compared to less than 20% of operations with annual sales less than $40,000 **(Figure 1)**.

Similarly, 70-90% of farms with crop operations and annual sales of $100,000 or more use conservation tillage, compared to 35-40% of farms with crop operations and annual sales of $10-40,000 and 20% of farms

Figure 3

Adoption of Water Protection BMPs by Farms Adjacent to Water Bodies by Farm Size

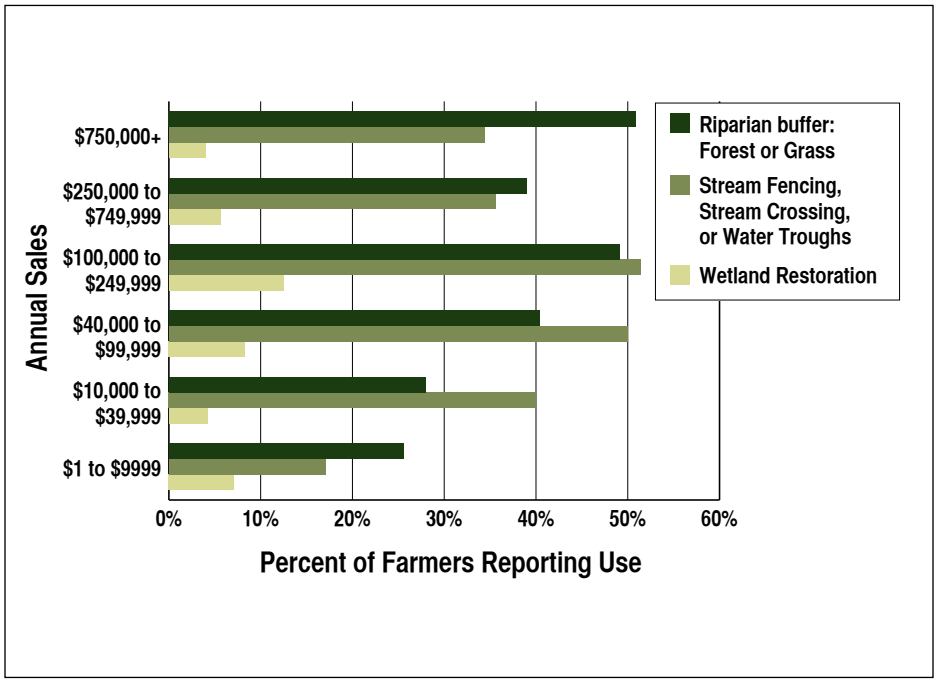
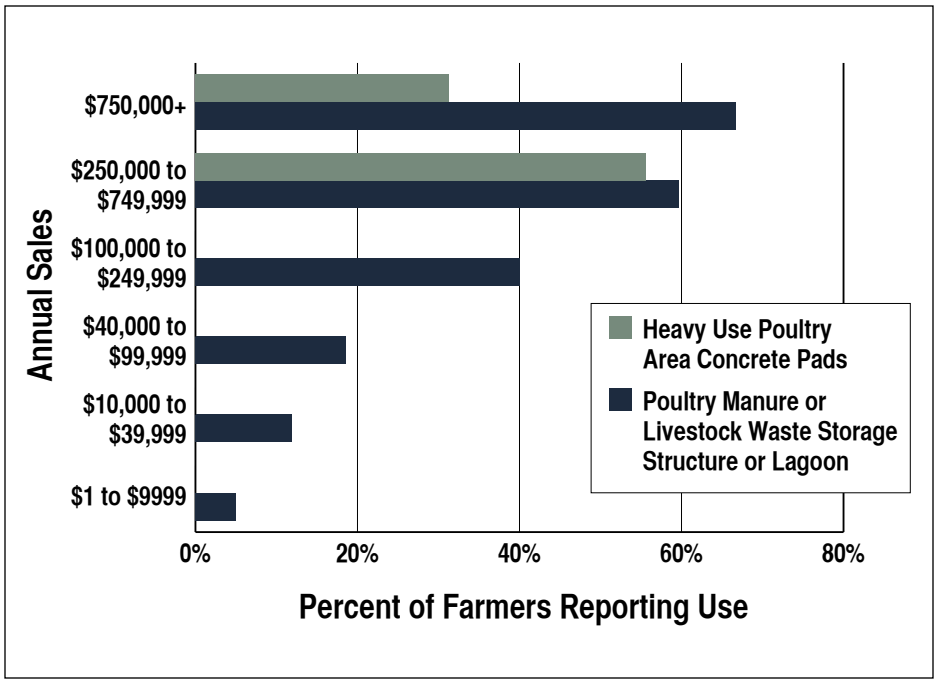


Figure 4

Adoption of Waste Management Structures by Farms with Livestock Operations by Farm Size



with crop operations and annual sales under $10,000 **(Figure 2)**. Also, 40-60% of farms with crop operations and annual sales of $100,000 or more use cover crops, compared to 10-15% of farms with crop operations and annual sales less than $40,000. Strip farming, contour farming, and retirement of highly erodible land do not generally show greater rates of adoption among the largest farms. **(Figure 2)**.

While there remains a trend towards larger farm adoption of BMPs, this trend is weaker for water protection BMPs **(Figure 3)**. Riparian buffers are more prevalent among farms with annual sales over $40,000. Stream fencing, stream crossings and water troughs - measures intended to keep livestock out of streams - are relatively prevalent among all but the smallest farms with livestock and land directly adjacent to water bodies. The prevalence of wetlands restoration among farms with land directly adjacent to wetlands is extremely low for all farm sizes.

Heavy use poultry area concrete pads are used only by farmers with at least $250,000 in annual sales **(Figure 4)**. Adoption rates of waste storage structures are increasing in farm size and are highly prevalent only among farmers with livestock and at least $100,000 in annual sales.

Table 2A

Share of Selected BMP Adoption Financed by Cost Sharing by Farm Size

ANNUAL SALES	VEGETATIVE COVER	WATER CONVEYANCE AND STORAGE	POULTRY MANURE OR LIVESTOCK WASTE STORAGE STRUCTURE OR LAGOON	HEAVY USE POULTRY AREA CONCRETE PADS
1 TO 9999	9.1%	17.6%	25.0%	NA
10,000 TO 39,999	13.3%	33.3%	42.9%	NA
40,000 TO 99,999	20.0%	47.4%	62.5%	NA
100,000 TO 249,999	45.0%	61.1%	55.6%	NA
250,000 TO 749,999	15.8%	46.7%	43.2%	40.0%
750,000 +	41.7%	47.8%	71.4%	60.0%

Table 2B

Share of Water Protection BMP Adoption Financed by Cost Sharing by Farm Size

ANNUAL SALES	RIPARIAN BUFFER: FOREST	RIPARIAN BUFFER: GRASS	WETLAND RESTORATION	STREAM FENCING, STREAM CROSSING, OR WATER TROUGHS
1 TO 9999	26.7%	8.3%	0.0%	28.6%
10,000 TO 39,999	28.6%	23.8%	100.0%	33.3%
40,000 TO 99,999	23.1%	29.4%	100.0%	56.3%
100,000 TO 249,999	46.7%	39.1%	50.0%	44.4%
250,000 TO 749,999	25.0%	25.0%	100.0%	43.8%
750,000 +	30.0%	48.1%	100.0%	81.8%

Table 2C

Share of Crop BMP Adoption Financed by Cost Sharing by Farm Size

ANNUAL SALES	COVER CROP	CONSERVATION/ NO TILL	CONTOUR FARMING	STRIP FARMING	RETIREMENT OF HIGHLY ERODIBLE LAND
1 TO 9999	18.2%	4.5%	0.0%	0.0%	20.0%
10,000 TO 39,999	28.6%	12.1%	11.1%	0.0%	0.0%
40,000 TO 99,999	50.0%	5.7%	0.0%	5.3%	22.2%
100,000 TO 249,999	64.3%	12.5%	7.1%	7.1%	0.0%
250,000 TO 749,999	62.3%	8.5%	14.3%	0.0%	25.0%
750,000 +	81.2%	13.2%	9.1%	18.2%	20.0%

Cost Sharing and Farm Size

By and large, there is much less evidence of a systematic relationship between receipt of cost sharing and farm size **(Tables 2A-C)**. Except for forest buffers, cost share is lowest on farms with sales less than $10,000. The only BMP with a strong relationship between sales and cost share is cover crops where 60-80% of farms with at least $100,000 in sales planting cover crops received cost sharing, compared to 20-30% of farms with under $10,000 in sales.

Intensity of Conservation Effort

Maryland farms are quite diverse. Many farms have variable topography and are diversified in terms of crop and livestock production. As a result, those farms require conservation strategies that incorporate a number of different BMPs. Figure 5 shows the extent of conservation effort exerted by individual farms, measured as the number of practices used.[5]

PHOTO: CHESAPEAKE BAY PROGRAM/WWW.CHESAPEAKEBAY.NET

Many Maryland farmers use a combination of different best management practices to protect their fields from erosion and runoff.

On the positive side, two-thirds of all farms use at least one BMP. On the negative side, a third of farms in our sample use none of these conservation practices and an additional fifth use only one.

[5] For Figures 5 and 6, forest and grass buffers have been combined and are thus counted as a single practice.

Farms that implement larger numbers of BMPs receive greater support in terms of cost sharing **(Figure 6)**. On average, only about one out of seven farms implementing a single BMP received cost sharing. By comparison, farms implementing 2 to 6 BMPs received cost sharing for 25-30% of those practices while farms implementing 9 to 11 BMPs received cost sharing for half to two-thirds of the BMPs used. On average, each additional BMP adopted increased the share of practices receiving cost sharing by 5-6 percentage points.

Nutrient Management

The Maryland Water Quality Improvement Act of 1998 (WQIA) required agricultural operations with a gross income above $2,500 or sales of more than eight animal units in the state of Maryland to develop and implement a nutrient management plan by December 31, 2002. A further requirement entails that this plan must be updated every three years.

Maryland farmers are required to manage fertilizer and manure applications by following the science-based guidelines for nitrogen and phosphorus inputs in their nutrient management plans. The goal is to optimize nutrients for plant production while minimizing nutrient loss. Nutrient

Figure 5

Number of Best Management Practices per Farm

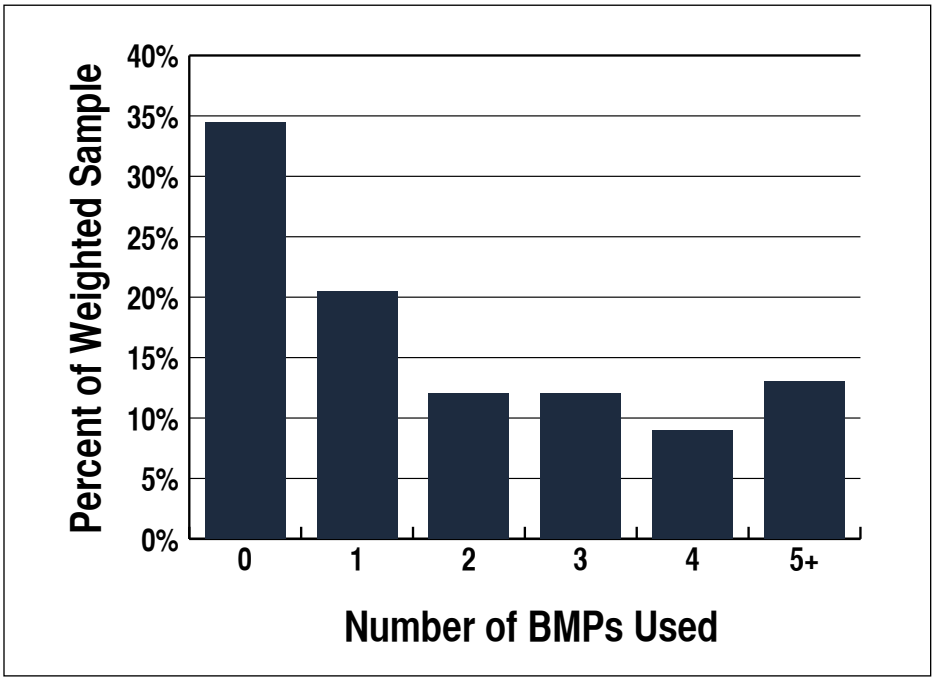
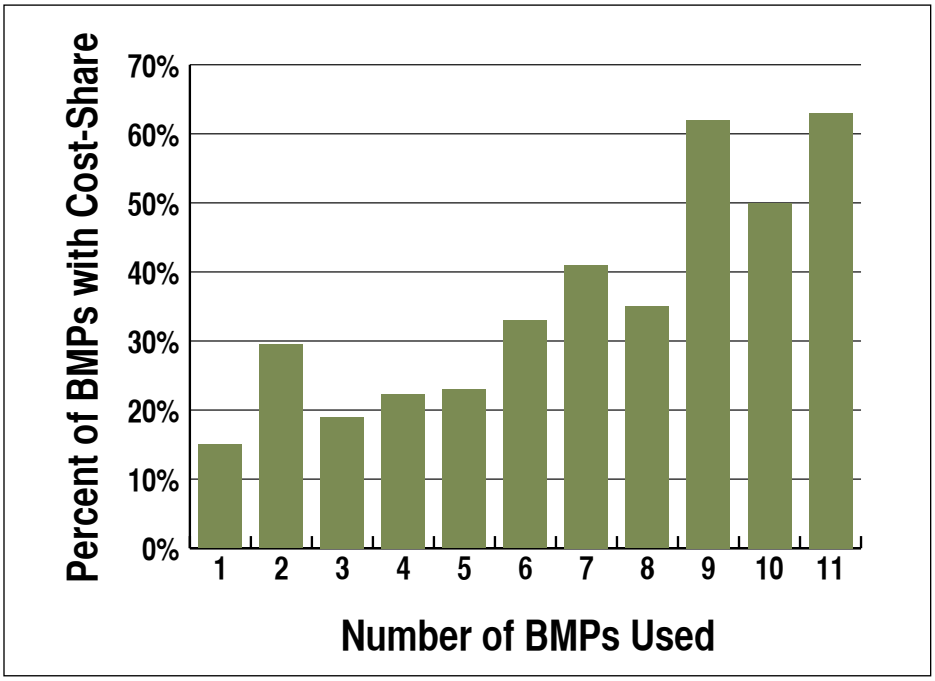


Figure 6

Percent of BMPs Used with Cost-Share by Number of BMPs Used



management plans outline the rate, timing, source, form and method of placement of nutrients for each crop. To achieve this, various conservation practices can be implemented along with the application guidelines.

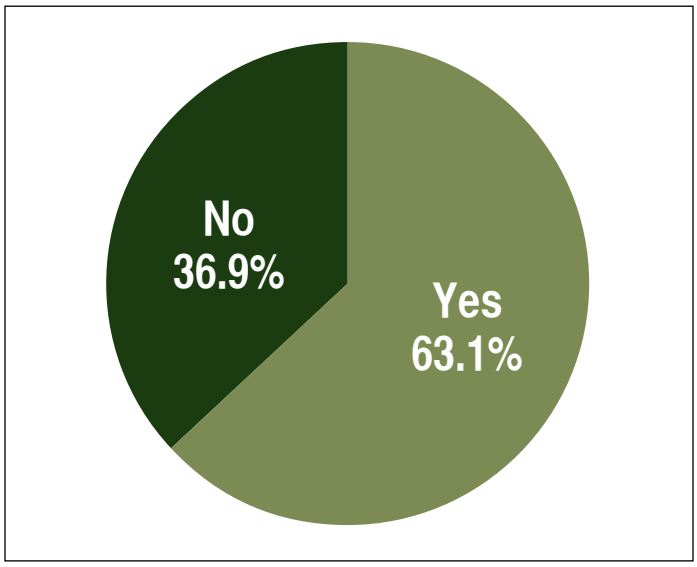
Nutrient management plans can be prepared by University of Maryland Extension personnel, certified chemical and fertilizer dealers, certified independent consultants or certified farmers and can be written for up to three years of implementation. Maryland's Nutrient Management Program provides financial and technical assistance to farmers to help them meet requirements of the WQIA. Maryland Department of Agriculture (MDA) is responsible for regulatory compliance and enforcement and an annual report is produced highlighting the previous year's compliance assurance and enforcement measures. Cost-share for private sector development of plans is available from MACS or EQIP. Funding is provided by state general funds and the Chesapeake and Atlantic Coastal Bays Trust Fund to support MDA regulatory compliance and UMD Extension technical assistance to farmers.

Plan Compliance

Based on survey responses and expanding this information to the weighted sample, approximately 12 percent of the weighted sample reported sales less than $2,500 and less than 8 animal units[6] and are thus not required to have a nutrient management plan.[7] As can be seen from Figure 7, of those in our sample who are required to have a nutrient management plan, 63 percent have a plan while the remaining 37 percent do not, indicating that compliance with WQIA requirements is far from complete.

Figure 7

Percent of Farms Required to Have a Nutrient Management Plan with a Nutrient Management Plan



Compliance varies systematically with farm size **(Figure 8)**. Only 3-4% of farms with at least $250,000 in annual sales that are required to have a nutrient management plan do not have one; 85-90% of farms with annual sales between $40,000 and $250,000 that are required to have a nutrient management plan do have one; and two-thirds of farms with annual sales between $10,000 and $40,000 that are required to have a nutrient management plan also have one. Compliance is quite low among small operations, though: Only a third of farms with less than $10,000 in annual sales that are required to have a nutrient management plan actually have one.

Plan Preparation

The traditional model of agricultural extension envisages extension personnel refining, demonstrating, and popularizing new farming

[6] USDA calculates animal units in terms of beef cattle equivalents. Thus, one beef cow equals one animal unit, one bird counts for 0.008 animal units, one dairy cow counts for 1.25 animal units, one pig represents 0.4 animal units, a single sheep, goat, or lamb counts for 0.1 animal units, and a horse represents 2 animal units.

[7] Of the 12% of operations that are not required to have a nutrient management plan, 8% have one even though they are not required to.

Figure 8

Nutrient Management Plan Compliance by Farm Size

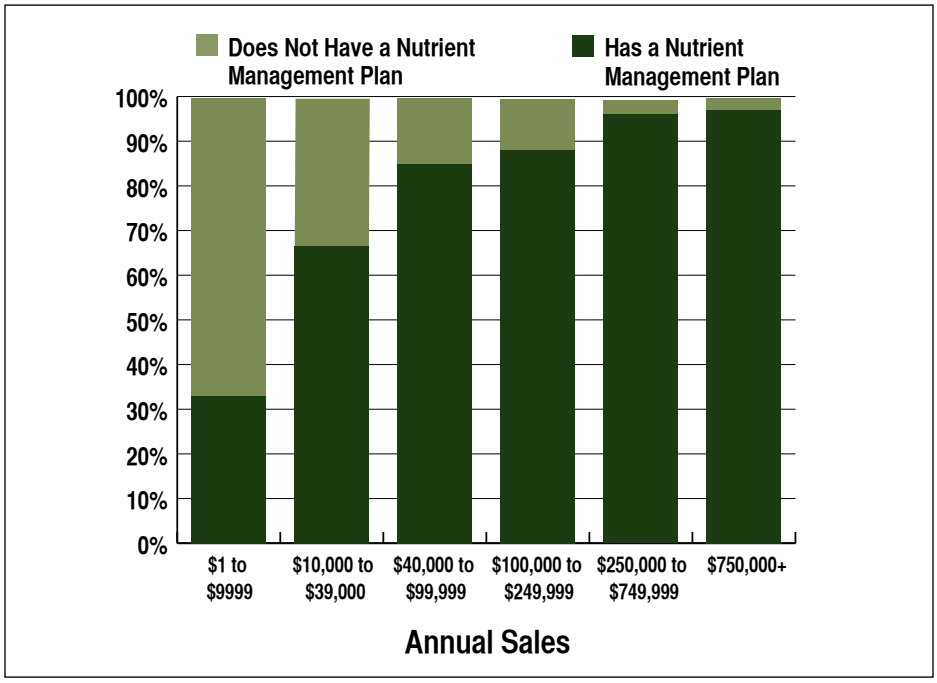
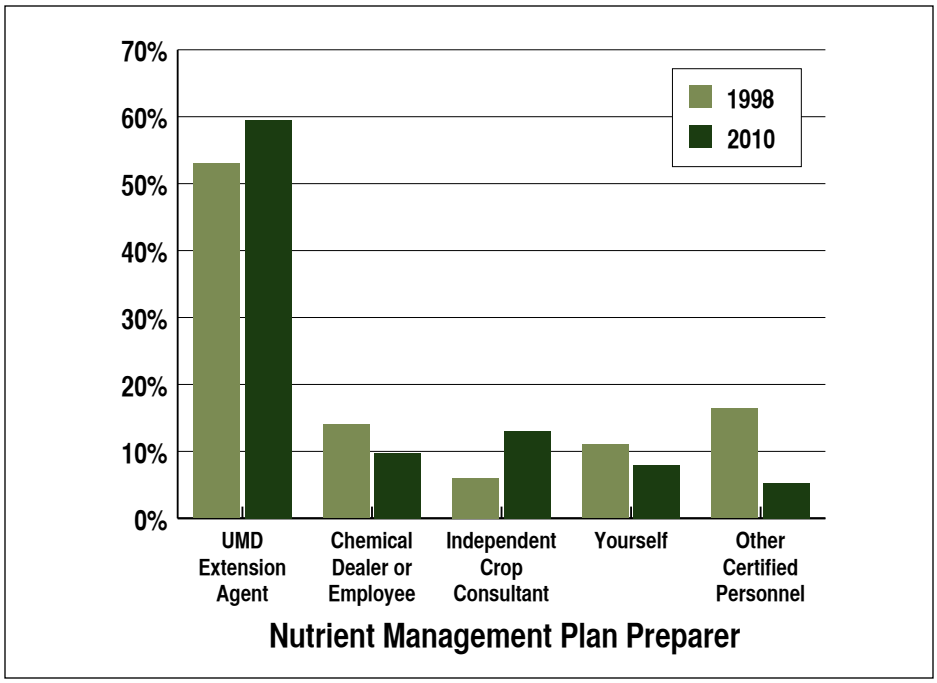


Figure 9

Preparation of Nutrient Management Plans by Preparer Type, 1998 and 2010



methods, then training farmers and consultants to implement those methods themselves, with a goal of eventually transferring all activity to the private sector. In the case of nutrient management planning, the State of Maryland has provided additional funds for University of Maryland Extension (UME) to write nutrient management plans and to train and certify crop consultants and farmers to prepare plans themselves.

A comparison with data obtained from a survey conducted in 1998, before the implementation of the WQIA, shows that the decade following WQIA implementation has witnessed an increase rather than a decrease in UME involvement in writing nutrient management plans **(Figure 9)**.[8] That comparison also shows increases in the professionalization of plan preparation, with larger shares of plans being written by UME personnel and by independent crop consultants and smaller shares being written by farmers, other certified personnel, and chemical dealer employees.

Nutrient Targeting

Prior to the WQIA, most nutrient management plans focused on managing nitrogen

[8] Lichtenberg, Erik and Doug Parker, "Nutrient Management in Maryland: A 1998 Snapshot", Economic Viewpoints, Department of Agricultural and Resource Economics, University of Maryland, College Park, Winter 2001.

Figure 10
Frequency of Soil Testing

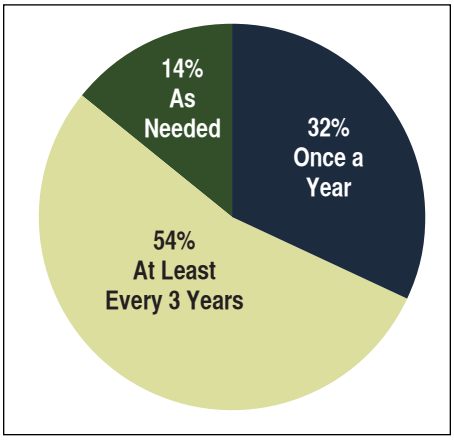
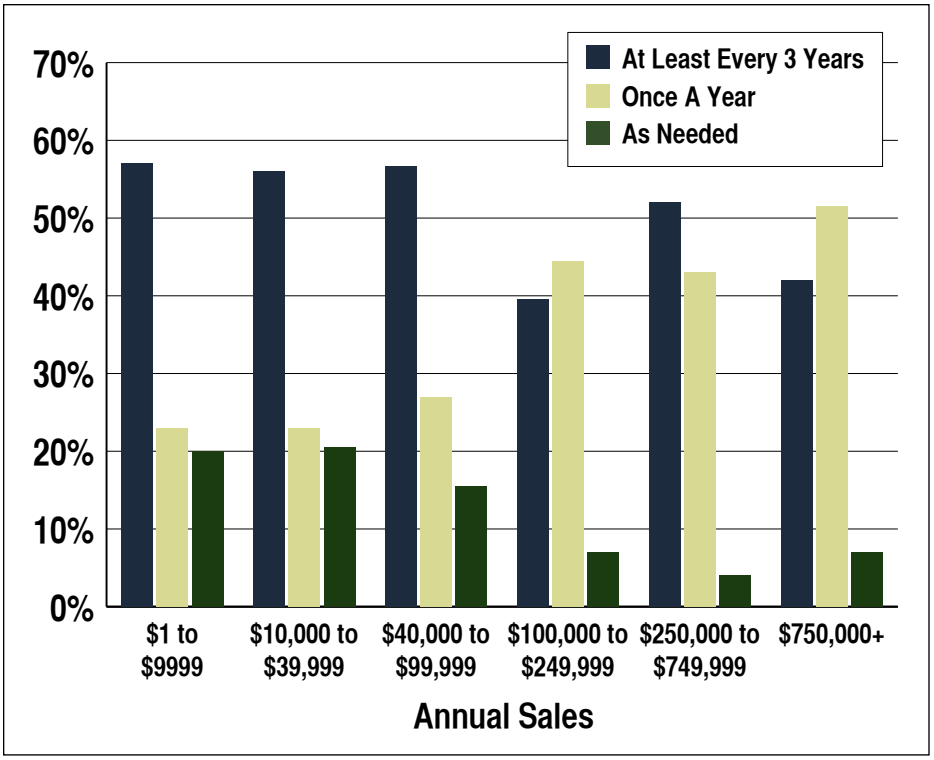


Figure 11
Frequency of Soil Testing by Farm Size



because of its greater mobility, which offered greater risk for mismanagement and greater reward for proper management (i.e. increased yield). In contrast phosphorus was generally understood to be less mobile in soils and therefore be at less risk for loss. However, by the time the WQIA was passed it had become widely understood that soils could become saturated with phosphorus, allowing for phosphorus transport to surface water through surface or subsurface pathways.

In recognition of the runoff risk from phosphorus on some soils, the 1998 WQIA regulations call for nutrient management plans to be phosphorus or nitrogen based, depending on soil tests and application of the Phosphorus Index. According to the survey, 41 percent of farms had plans that are phosphorus based, compared to 35 percent with nitrogen based plans. The larger percentage of phosphorus based plans supports the scientific findings that phosphorus can be the primary pollutant of concern when soil phosphorus levels are high and for specific topographies and soil types.

Nutrient Testing

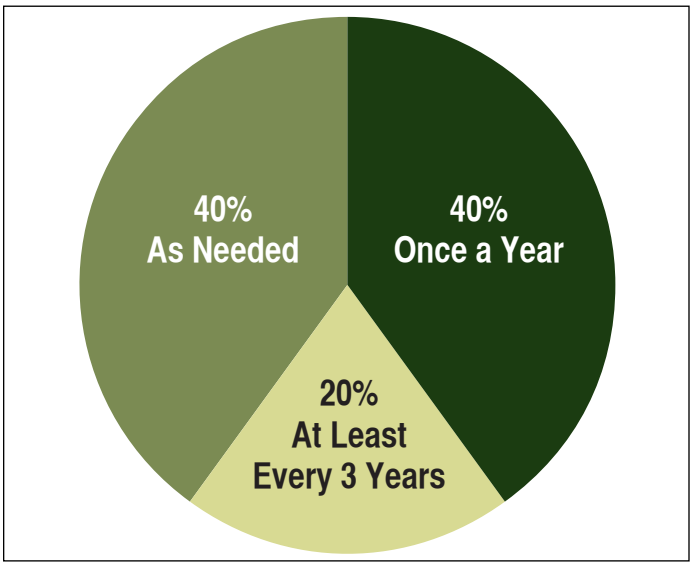
Soil and manure nutrient content testing are key components of a nutrient management plan. Figures 10 and 11 present information on the frequency of such tests. According to Figure 10, the majority of farms in our weighted sample test their soil at least once every three years, the time frame

PHOTO: EDWIN REMSBERG

Soil tests use soil samples like these to provide the information needed to develop nutrient management plans.

Figure 12

Frequency of Manure Nutrient Content Testing



specified by the WQIA. A substantial number of farms in our weighted sample test their soil more often: Almost a third report testing annually, i.e., more frequently than required by law.

There is some variation in the frequency of soil testing across farm size **(Figure 11)**. Operations with annual sales of at least $100,000 are more likely to report testing soil once a year than smaller operations, while operations with annual sales under $100,000 are more likely to report testing soil as needed than larger operations.

Manure nutrient content is often more variable than soil nutrient content so frequent testing is needed to ensure that manure nutrients are credited accurately. Figure 12 indicates that 40 percent of respondents with plans test at least once a year, 20 percent test at least once every three years and 40 percent test as needed. These data thus suggest that manure testing does occur more frequently than soil testing; however, the non-response rate for this question was quite high (39%), so that this conclusion can only be considered tentative.

Nutrient Management Plan Content

The survey asked a number of questions related to specific practices that might be incorporated into a nutrient management plan, including some enhanced precision agriculture techniques of special interest that can be used to refine nutrient application rates. The prevalence of all of these nutrient management practices is quite low. The most widely used, fertilizer incorporation, is used only in about a third of nutrient management plans **(Table 3)**. Enhanced techniques are much less widely used: Between a twentieth and a tenth of farms report using any of these practices. These data are not surprising considering enhanced nutrient management and precision agriculture techniques are relatively new and the technology and equipment to implement these techniques not widely available. The ratio between farmers not receiving to receiving cost-share is also not surprising as only two of the practices, manure transport and precision agriculture, were eligible under federal or state cost-share programs during the 2009 season. However, NRCS and non-government organizations provided funding through pilots, grants and demonstrations for the remaining practices. As with conservation BMPs, most nutrient management practice use is self-funded.

PHOTO: EDWIN REMSBERG

Poultry litter provides nutrients and improves soil quality for crops like corn.

Table 3

Nutrient Management Practices and Cost-Share Participation

	PERCENT OF FARMS USING EACH PRACTICE			
	USE	NOT RECEIVING COST-SHARE	RECEIVING COST-SHARE	RATIO NOT RECEIVING TO RECEIVING COST-SHARE
Conservation Practices Included in Nutrient Management Plan				
FERTILIZER INCORPORATION / INJECTION	32.7%	30.9%	1.7%	17.7 : 1
MANURE INCORPORATION / INJECTION	20.8%	18.7%	2.1%	8.9 : 1
MANURE TRANSPORT	11.4%	10.1%	1.4%	7.3 : 1
AMMONIA EMISSION REDUCTION	4.7%	4.0%	0.7%	6.1 : 1
PRECISION AGRICULTURE	12.7%	10.6%	2.0%	5.3 : 1
OTHER BMPS	10.6%	6.5%	4.2%	1.6 : 1
Enhanced Techniques				
AERIAL IMAGERY AND STRIP TRIALS	4.5%	3.8%	0.7%	5.6 : 1
CORN STALK NITRATE TESTING	8.1%	6.3%	1.8%	3.5 : 1
PLANT AND GRAIN ANALYSIS	9.1%	8.3%	0.9%	9.7 : 1
OTHER BMPS	4.7%	3.8%	0.9%	4.5 : 1

In general, larger operations are more like to have nutrient management conservation practices included in their nutrient management plans **(Figures 13A,B)**. Over two-fifths of operations with annual sales of $750,000 or more report having precision agriculture incorporated into their nutrient management plans, compared to a fifth of operations with annual sales between $250,000 and $750,000 and less than a tenth of operations with annual sales under $250,000. Roughly 40% of operations with annual sales of $250,000 or more report having manure incorporation/injection included in their nutrient management plans compared to a quarter of operations with annual sales between $100,000 and $250,000 and under 15% of operations with sales under $100,000. Fertilizer incorporation/injection shows a similar pattern, although it remains more common than manure incorporation/injection in nutrient management plans on smaller operations. Inclusion of manure transport and ammonia emission reduction measures in

Figure 13A

Prevalence of the Most Common Nutrient Management Conservation Practices Included in Nutrient Management Plans by Farm Size

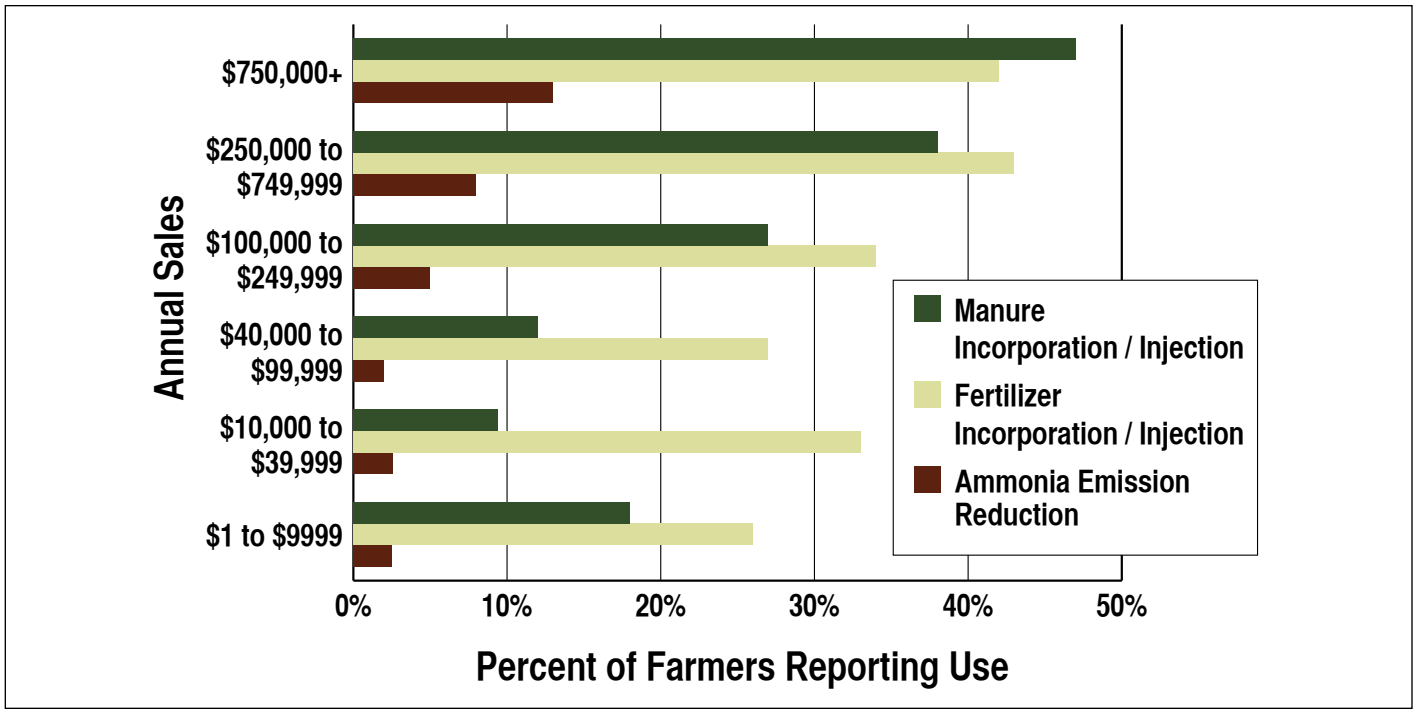


Figure 13B

Prevalence of Less Common Nutrient Management Conservation Practices Included in Nutrient Management Plans by Farm Size

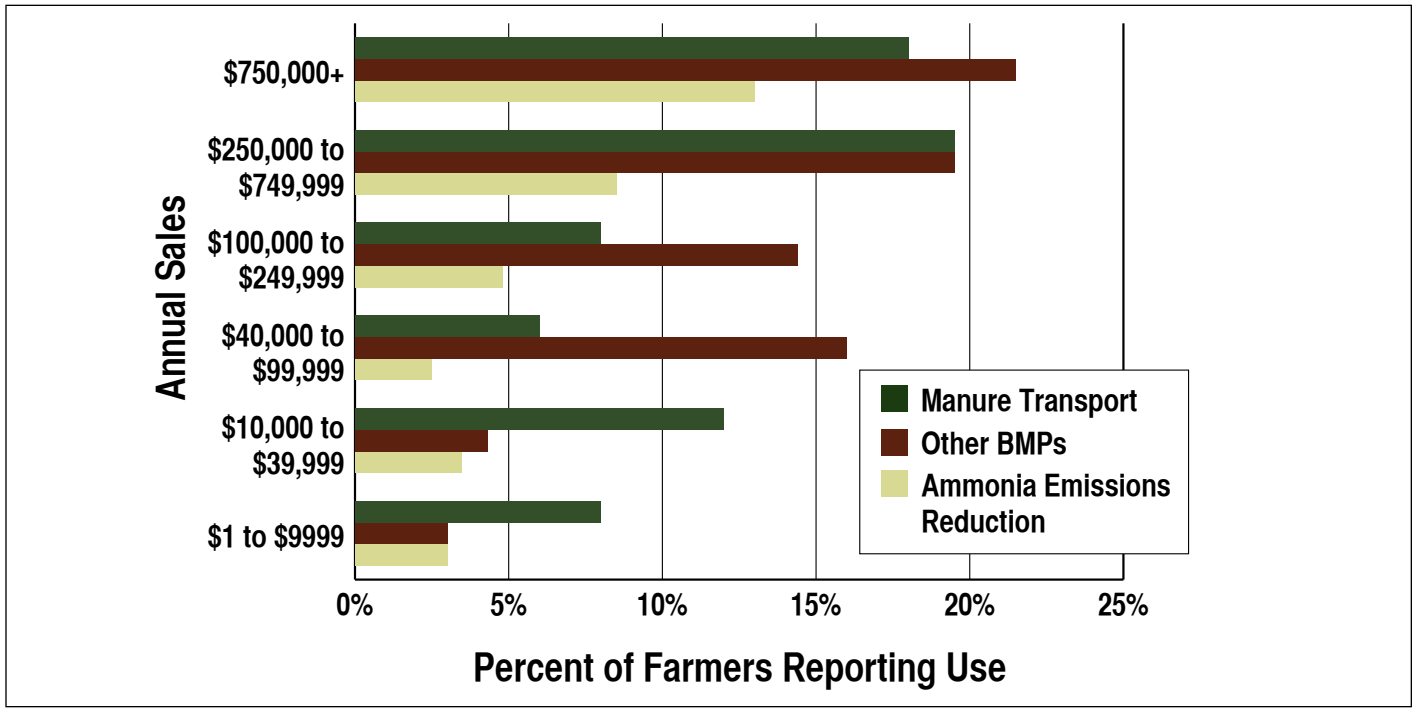


Figure 14

Prevalence of Enhanced Techniques by Farm Size

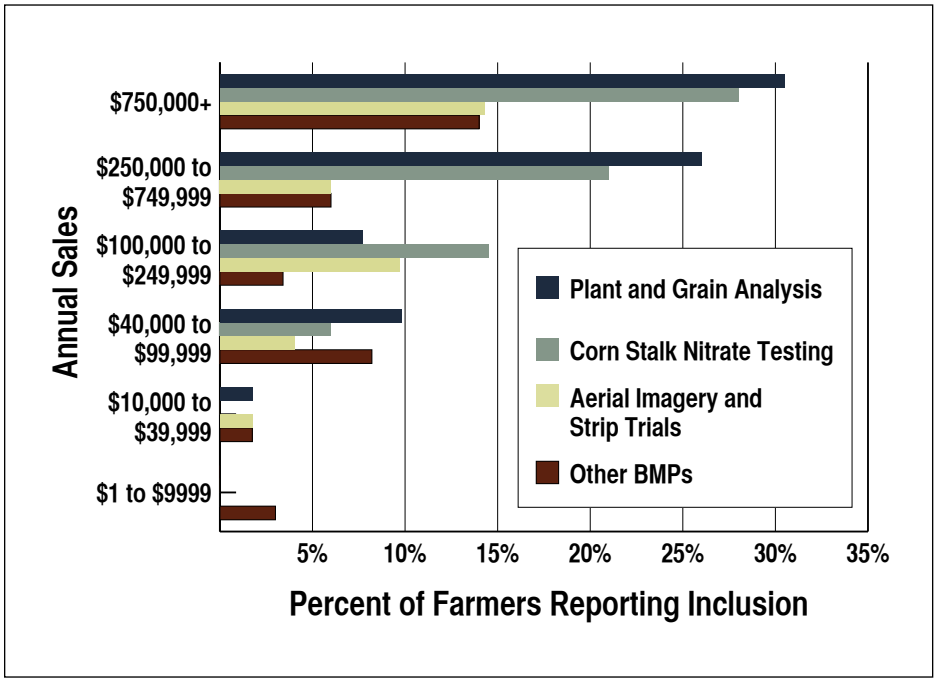
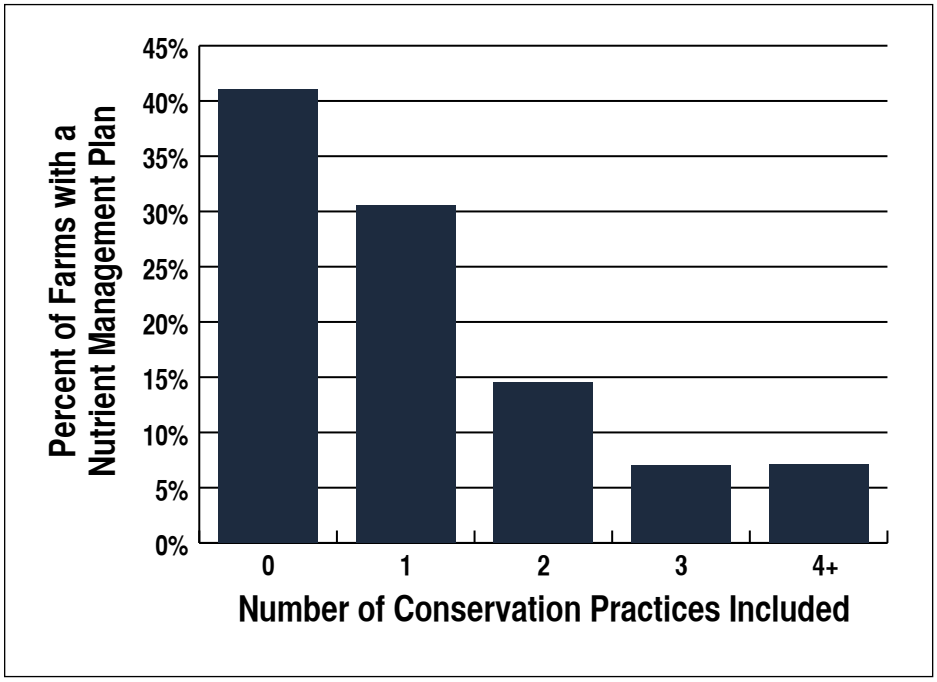


Figure 15

Number of Conservation Practices Included in the Nutrient Management Plan



nutrient management plans is also increasing in farm size.

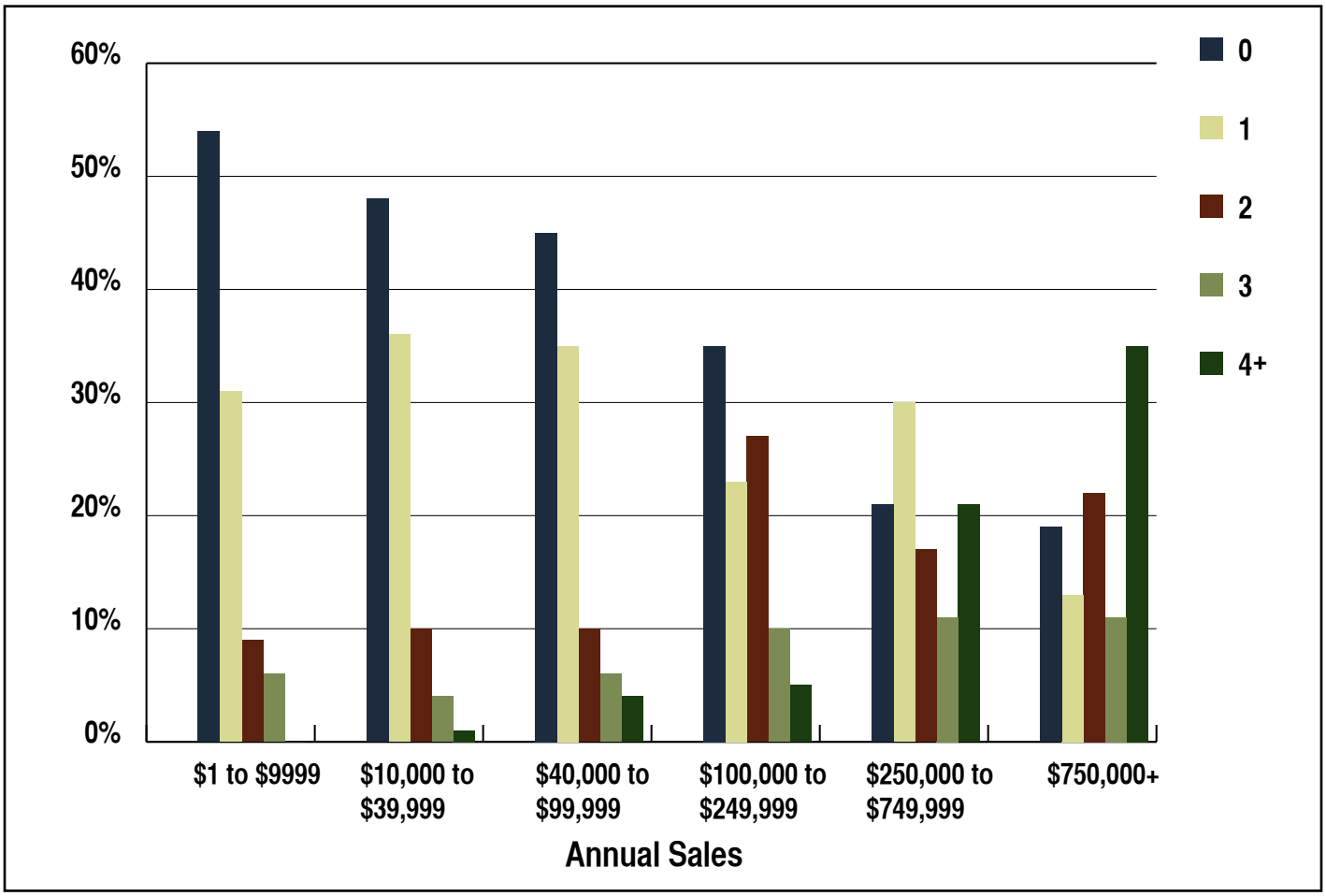
The use of enhanced techniques like aerial imagery and strip trials, corn stalk nitrogen testing, and plant and grain analysis, while not widespread, is similarly more prevalent on larger operations than smaller ones **(Figure 14)**. Between a quarter and a third of operations with annual sales of $250,000 or more report using plant and grain analysis while 20-30% report using corn stalk nitrogen testing. In contrast, none of the operations with annual sales less than $40,000 reported using plant and grain analysis and only 1% report using corn stalk nitrate testing. Aerial imagery and strip trials and other BMPs, while less prevalent, are similarly more likely to be used on larger operations than smaller ones.

Nutrient management plans exhibit less complexity than conservation efforts. Over 40% of the farms with nutrient management plans reported having none of these nutrient management practices in their plans **(Figure 15)**. About 30% of the farms with nutrient management plans reported having only one practice in their plans; only about an eighth use three or more.

Not surprisingly, larger operations have more complex

Figure 16

Number of Conservation Practices Included in the Nutrient Management Plan by Farm Size



nutrient management plans than smaller ones (Figure 16). Over a third of operations with annual sales of $750,000 or more have at least 4 conservation practices included in their nutrient management plans while an additional 30% have 2 or 3 conservation practices included in their nutrient management plans. All operations with annual sales of $750,000 or more had at least one of these conservation practices included in their nutrient management plans. In contrast, over half of operations with less than $10,000 in annual sales, 40-50% of operations with annual sales between $10,000 and 100,000, and about a third of operations with annual sales between $100,000 and $250,000 have none of these conservation practices included in their nutrient management plans.

Conclusions

Promoting adoption of BMPs has been the centerpiece of efforts to meet water quality goals in the Chesapeake Bay for over a quarter of a century. The 1998 Maryland WQIA accelerated those efforts by requiring nutrient management plans for commercial farm operations. Compliance with TMDL water quality regulations is likely to require even more widespread use of BMPs and may require expansion of existing policies or development of new policies.

This report provides an overview of current use of BMPs and characteristics of nutrient management plans in Maryland a decade after implementation of the WQIA. Data from a survey of Maryland farmers indicates that the use of most BMPs is not widespread: In most cases, small minorities of farmers with applicable operations use any of the most common BMPs. Over a third of farms do not use any conservation BMPs and over two-fifths do not have conservation management BMPs written into their nutrient management plans. The use of BMPs varies markedly according to farm size, with larger operations substantially more likely to use almost all BMPs than smaller ones.

Among farms that do use BMPs, conservation efforts can be quite complex, as indicated by the fact that a third of farms report using three or more BMPs while an eighth of farms with nutrient management plans have three or more nutrient management practices written into their plans. Again, larger operations are more likely to use larger numbers of BMPs and to have larger numbers of conservation practices written into their nutrient management plans.

Maryland has used funding from federal and state sources to provide cost sharing of BMP implementation as a means of expanding BMP use. Data from this survey indicate that the reach of cost sharing has been limited: With only one or two exceptions, BMP usage is overwhelmingly self-funded by farmers. Cost sharing appears to have been concentrated on more complex conservation efforts on larger, more diverse operations: Farmers reporting using 9 to 11 conservation BMPs received cost sharing for half to two-thirds of the practices they used, while only a sixth of farmers using one BMP reporting having received cost sharing. Larger operations were substantially more likely than smaller ones to receive cost sharing for the most commonly used BMPs, including cover crops, conservation tillage, vegetative cover, riparian buffers, waste storage structures, and heavy use concrete pads for poultry.

Although nutrient management planning has been required under the WQIA for a decade, compliance with that requirement is surprisingly low. The data from this survey indicate that over one-third of the farmers required to have a nutrient management plan reported not having one. Compliance with nutrient management planning requirements varies markedly across farm size, however, with almost all large commercial operations reporting having a nutrient management plan and almost a third of very small operations reporting not having one despite meeting the qualifications that make having one mandatory. Nutrient management BMPs are less prevalent than conservation BMPs and are self-funded to an even larger extent. On the positive side, recognition that phosphorus can cause runoff problems has led to a greater prevalence of nutrient management plans targeting phosphorus.

Overall, these findings suggest that there is likely considerable capacity for further reductions in nutrient and sediment runoff through BMP adoption in Maryland agriculture. The greatest potential appears to lie in promoting adoption among smaller operations, although usage rates of many BMPs could likely be increased among larger operations as well. It might appear cost effective to target larger operations because they account for the bulk of cropland, numbers of most kinds of livestock, and overall farm activity. But, small operations still account for significant shares of agricultural activity in the state. According to the 2007 Census of Agriculture, farms with annual sales under $10,000 account for 10% of total cropland, 12% of cattle, and 68% of all horses in Maryland while farms with sales between $10,000 and $50,000 account for an additional 11% of cropland, 14% of cattle, and 15% of horses. In contrast, farms with annual sales of $500,000 or more account for 38% of cropland, 50% of cattle, and only 8% of horses. The relative contributions of small and large operations to nutrients and sediment in Maryland's waterways have never been documented and it remains quite possible that expanded use of BMPs offers greater potential for reducing nutrient and sediment runoff on smaller operations than larger operations. Determining whether that is the case seems a fruitful and important topic for further research.

The finding that there is likely considerable capacity for further reductions in nutrient and sediment runoff through BMP adoption in Maryland agriculture is, in one sense, a welcome one. If TMDL based water quality standards require reductions in nutrient runoff from agriculture—as is widely expected—BMP usage will need to become

much more widespread than at present. Achieving more widespread BMP usage may require expansion of programs like cost sharing both in terms of funding availability and in terms of the kinds of operations targeted for receipt. Alternative approaches to reducing nutrient and sediment runoff that are regulatory rather than voluntary in nature may also be needed.