Nitrogen Management Performance Guarantee System for Corn Producers in Pennsylvania: Feasibility to Improve Water Quality in Chesapeake Bay

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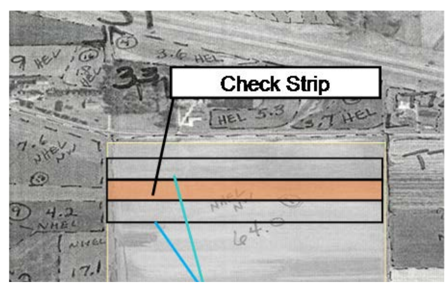
Foreword

In 2004, representatives of the Pennsylvania Department of Agriculture, Pennsylvania Department of Environmental Protection, Chesapeake Bay Commission, American Farmland Trust and the crop insurance industry met in Harrisburg to discuss results of the pilot Federal Crop Insurance Corporation Nutrient BMP Endorsement. This new crop insurance product was developed to help address the economic risks assumed by corn farmers when they reduce their nutrient applications to university-recommended rates. At a subsidized cost to the farmer of $3 per acre, the product also provided low-cost technical assistance from qualified crop advisors and third-party verification of nutrient-use reductions and impacts on farmer net income. If the farmer ended up losing more in yield than he or she gained in savings on fertilizer, the Endorsement made up the difference to the farmer in cash.

The Endorsement was a flop. Two crop insurance companies that had committed to offering the product backed out because of unrelated financial problems. Both folded soon afterwards. A third company was so busy up picking up traditional insurance policies from the failed competitors that it could not afford the time on what they considered to be a small niche-market product. Insurance agents were uncomfortable with the agronomic information required with the application. Farmers were reluctant to pay for the product and were more comfortable in continuing to add extra fertilizer as their own form of insurance. As a result, only three Endorsements were sold: two to farmers in Pennsylvania and one in Minnesota.



In each field, a qualified crop advisor carefully places a single set of check strips following a written protocol to reduce variability. The check strip receives the farmer's traditional practice and the rest of the field receives the new practice. To minimize impacts of within-field variability, yield comparisons at harvest use the immediately adjacent strips only.

Soon after, AFT and Agflex proposed an alternative approach, dubbed BMP CHALLENGE™ Guarantee System that was specifically designed to avoid the obstacles associated with crop insurance. The guarantee takes the form of a contractual service agreement between a farmer and Agflex, a new company formed for this purpose. The farmer would work with a crop advisor that was approved by and paid for by Agflex. Agflex would compensate the farmer for any net income shortfall. The guarantee used the same low-cost, single-check strip approach approved for the Endorsement after a rigorous scientific review. After developing a nutrient management plan or conservation tillage system with help from the advisor, the farmer used his conventional practice on the check strip, which was located precisely in the field by the crop advisor using a written protocol to minimize the possibility of in-field variations. The farmer then used the new Best Management Practice (BMP) on the rest of the field. At harvest, the crop advisor compared yield on the check strip to yield on the rows of corn located immediately adjacent to the strip, and reported the results to Agflex, which then computed net returns and compensated farmers for any losses.

From the perspective of AFT, the BMP CHALLENGE™ offered an effective solution to a major barrier to adoption of conservation practices; producer concerns that an unfamiliar practice may cause yield/profit loss compared to their traditional practice. By combining safety-net payments in case of loss, technical assistance from an experienced advisor, and a side-by-side comparison, the BMP CHALLENGE™ brought together the key elements of on-farm research, extension advice and risk management into a single package. If successful, this innovative new approach could be a powerful addition to the toolbox of federal, state and private farm advisors.

During the 2004 meeting on the potential use of the BMP CHALLENGE™ to encourage adoption of nutrient management in Pennsylvania, several individuals commented that they believed most farmers were already applying nitrogen at university-recommended rates. Others thought that there was sufficient conservatism built into the recommendations such that farmers could reduce applications further without significant impacts on yield. Some suggested that crops on droughty soils, where moisture limited yields more often than nutrients, could generate equivalent economic returns with less fertilizer. A concept that had appeared in print (referred to as yield reserve and enhanced nutrient management) was raised as a potential tool; this approach involved intentional application of less-than-recommended rates. Cost estimates suggested that the practice could be competitive with other conservation practices, such as cover crops and buffer strips, for reducing nitrogen runoff to Chesapeake Bay (Cost Effective Strategies for the Bay, Chesapeake Bay Commission, and December 2004).

Based on these comments, AFT developed a new project to test the below-recommended application of fertilizer. This approach is referred to as Planned Nitrogen Reduction (PNR), in which farmers are compensated for any losses resulting from applying nutrients at a level up to 15% below the recommended amounts using the BMP CHALLENGE™. Under this regime, AFT would offer the below-recommended-rate guarantee at no cost to the farmer and provide a cost-share payment of $15 to $30 per acre, depending on the nitrogen reduction, to compensate farmers for their participation. With funding from the Pennsylvania Department of Agriculture (PDA), Chesapeake Bay Commission, Iowa Department of Economic Development, American Farmland Trust and others, the pilot was launched in 2005 in two fields and expanded to 18 fields in 2006.

Through 2010, we have implemented what was initially termed enhanced nutrient management and subsequently renamed “Planned Nitrogen Reduction” (PNR) on 100 fields and more than 9000 acres, nearly all in Pennsylvania. To date, participating farmers have reduced nitrogen (N) applications by nearly 250,000 lbs. and prevented losses of more than 30 tons of N to surface water. We have also implemented more than 7000 acres of the Nutrient BMP CHALLENGE® (N rates reduced **to** rather than below LGU rates) and Reduced Tillage BMP CHALLENGE® across the corn belt, reducing N use by more than 180,000 lbs. and sediment loading by 3400 tons and phosphorus by more than 4600 lbs. One Pennsylvania farmer described his participation in this pilot as follows:

"In 2006, I met with Jedd Moncavage from TeamAg. He described a new project they were looking for farmers to participate in. They wanted farmers to cut N applications by 15% below what they had been recommending. This was a very different approach to think about reducing N. My main concern is profit. Usually we are looking at pushing production, trying to maximize our return. There really was not much risk. I would get a payment for participating and another payment if I lost money on the crop. I agreed with the conservation end and wanted to know that I was not losing N into the stream. The Bay is certainly a problem. It's a big problem. This means less nitrogen out there. If you get a big rain, there is just not as much to run off. The fact that there was no economic risk made it seem like a good thing to try.

It was a good experience. It really was not a lot of extra work for me. They (Team Ag) came out and did the in-field work and (supervised) the harvesting. I lost yield and it was covered. I was selling silage so I didn't have to replace it. It was interesting to see if we would have the same result the second year and the third year and the fourth year. We always seemed to have a loss in the seven to eight percent range. I didn't participate in this year. I felt that I had learned what there was to learn and didn't want to participate.

I also used the BMP CHALLENGE for no till for two years. I had not used no-till at all before that. The guarantee was probably 80% of the reason I decided to try no till. I was concerned about the yield impact. There was lots of risk of whether it would pan out over two to three years. The equipment is expensive. But I did try it and I am really pleased. I would have tried it sooner if the yield risk had been taken care of.

I probably had a small yield hit last year. I had a problem with a rye cover crop that I sprayed and cold temperatures made me have to spray again. It seems like there are more possible bugs that can go wrong with no till. But on most fields for most years I have been happy with it. This year I no tilled everything.

I haven't really worked with Extension or the district. This is the first crop advisor I had worked with and still is. I am thinking of using them next year. I'd like to get their whole advice package."

Executive Summary

By many measures, the Chesapeake Bay is falling short of its potential to provide vital ecological services, food production and recreational uses. Nitrogen (N) pollution represents the most critical impairment because it accelerates algal growth and reduces the oxygen levels required by aquatic organisms. Agriculture is both the leading source of nutrients and a major contributor to the progress in reducing nutrient loading to date. Pennsylvania farmers alone have been responsible for 41% of all the N reductions from agriculture in the entire watershed. This report summarizes the results of a pilot project that demonstrates how a $6 million one-time investment can cover and deliver nearly 20% of Pennsylvania's commitment to N-load reductions on a sustained basis.

From 1985 to 2009, Pennsylvania achieved 28% of the N reductions required to meet its annual goal. The Commonwealth also established the largest Conservation Resource Enhancement Program in the nation, exceeding its 2010 goal for forest buffers along waterways and permanently preserving more than three million acres of land.

Pennsylvania has committed to an additional 29.5 million lbs. (lbs.) of N-load reductions annually by 2025. While Best Management Practices (BMPs) have potential to meet and exceed agriculture's contribution to this commitment, they are not universally adopted in large part because farmers need more information, technical support and less economic risk to implement them. This unmet potential is critical as our nation asks agriculture to continue to help meet soaring food and energy needs for an additional five million people in the Chesapeake Bay region and 2.4 billion people worldwide during the next 40 years, as well meet as landscape and ecological diversity goals.

N management is particularly challenging for corn farmers who must determine how much to apply without advance knowledge of key determinants of crop need including weather. Pennsylvania State University (PSU) advises producers to apply N as close to crop need as possible, with 50% to 90% of the nutrient applied after corn is ten to 20 inches tall, typically in late spring. At that point, soil or leaf-chlorophyll tests may be used to more accurately predict N need, particularly in fields with a recent history of manure application or legume production. Adoption of testing and application in the late spring is thought to be low, although accurate and recent data specific to Pennsylvania farm practices are not available. Based on 2005-2007 data from the USDA's Natural Resources Conservation Service (NRCS), less than one-half of corn fields in the Chesapeake Bay region benefit from late spring applications, and many fewer from tests to refine application amounts. NRCS's Conservation Effects Assessment Project (CEAP) report for the Chesapeake Bay found that approximately 22% of cropped acres have a low level of nitrogen management meaning some or all crops in rotation exceed criteria for rate and either timing or method.

The BMP CHALLENGE™ system is an adaptive management approach to implementing BMPs that provides technical support, a net income guarantee, and verification of practices and net returns for farmers so that farmers can learn how new practices perform on their farms. The approach has been used to support adoption of nutrient management and conservation tillage in corn and has enrolled more than 16,000 acres across 12 states. Participants have reduced N applications by nearly 425,000 lbs. and prevented loss of more than 3400 tons of sediment and 4600 lbs. of phosphorus on enrolled acres.

The BMP CHALLENGE supports participants who follow Land Grant University (LGU) recommendations for nutrient management and who implement tillage systems that maintain at least 30% residue. These programs do not provide a farmer cost share and are intended for short-term participation, typically on one or two fields, until the farmer becomes comfortable with the BMP or learns how to adapt and manage the BMP on his/her farm. Most participants adopt the BMP in full or in part, and across most of their acreage, after just one year of participation.

In Pennsylvania, the guarantee system has been used primarily for Planned N Reduction (PNR), also historically referred to as enhanced nutrient management or yield reserve. PNR is an approach for achieving water quality objectives whereby farmers apply N at levels below the LGU-recommended rates. The method is also designed for potential ongoing farmer participation in watersheds where nutrient impairments would remain, even if all farmers followed LGU recommendations. In PNR, unlike the BMP CHALLENGE, farmers have been provided with a cost-share payment in addition to the net income guarantee. In contrast to the BMP CHALLENGE, PNR incurs ongoing costs to maintain N use, loss and load reductions.

Findings, Conclusions and Recommendations[1]

Based on the feasibility study data collection and analysis of field experience in Pennsylvania and the eleven other states where the conservation yield guarantee BMP CHALLENGE has been implemented, we have five main findings along with conclusions and recommendations. These address the most pertinent project objectives and queries from our project partners, as well as layout potential next steps in achieving the ultimate goal of reducing nutrient loading by accelerating adoption of conservation practices.

1) **Planned Nitrogen Reduction (PNR)**—reducing nitrogen loading by applying nitrogen fertilizer at rates *below* the land grant university recommendations.
   Findings
   a) **PNR reduced nitrogen use and nitrogen loadings:** PNR participants reduced N applications by 15% on average, about 27 pounds below LGU recommendations. Between 2005 and 2010 they reduced N use by over 244,000 pounds (i.e., in-field pounds of N fertilizer applications). These application reductions translate to 7.8 pounds per acre or 70,800 pounds of nitrogen reduced in

[1] Note that additional recommendations are found in Section 6, Recommendations, p. 53

the Chesapeake Bay (i.e., N-load reductions delivered to the Bay), using an average efficiency conversion rate of 29%.

b) **But PNR also on average reduced yields and caused negative net returns:** Along with the N reductions, participants experienced a 7.3% yield loss translating to 11.9 bu. per acre on average. Despite the savings in fertilizer costs, farmers experienced a $35.29 loss per acre in net returns for those acres.

c) **In addition, utilizing advanced nutrient management techniques and targeting critical acres are likely to reduce yield impacts of PNR:** Numerous tools that improve nutrient use efficiency through management changes to the rate, timing, placement and product have been recommended to farmers for some time and continue to be developed. Analysis of the PNR data set for instance showed that producers who applied commercial N in more than one application (e.g., at or prior to planting, and a second application in late spring) experienced greater yields (and net returns) than for producers who made a single application .Use of additional and more sophisticated techniques hold the promise reducing negative returns even further.

d) **Moreover, farmers could cover net income losses and even generate net income with a robust water quality credit trading:** based on the project's experience with generating nitrogen credits, a water quality trading market could provide revenue to defray the cost of the N-loss reductions experienced using PNR. Trading could even become revenue positive under the right market conditions. Assuming an average reduction of 7.8 pounds nitrogen per acre delivered to the Bay and the current corn price of $6 per bushel, the price per pound of N would need to be approximately $15 per pound to cover full PNR program costs or $4.52 to cover the farmer's net loss of $35.29 per acre. While early credits have traded well below these levels, even as recently as 2010, many experts including the World Resources Institute project credit prices to rise to levels in the range of $20 per pound of nitrogen, which would generate net revenue for farmers.

e) **PNR yield losses indicate LGU recommendations do not have significant excess built into them:** a view voiced at the outset of this project (and echoed by some water quality advocates) asserted that LGU recommendations are above the optimum N use efficiency rate. This lead to the assumption that there were "easy" N reductions to be achieved simply by having farmers cut back the N applications. The PNR results indicate that a 10-15% level of reduction across the board on all fields would have a negative yield impact.

f) **Scaling up of PNR could add to regional corn deficit:** Given the yield impact, wide-spread adoption of the PNR would add to the region's corn deficit. Replacement of corn not produced using the PNR would entail an additional acre of corn for every 12.6 acres of PNR corn, assuming 150.5 bu. per acre as average production at LGU-recommended N rates.

Recommendation

Data suggest that the conditions that would consistently result in positive net returns from PNR (e.g., dramatic increases in nitrogen costs, steeply falling corn prices, or nutrient trading markets with nitrogen credit prices significantly exceeding $15) are unlikely to occur in the foreseeable future. In addition, for a number of reasons, including significant and consistent yield losses, the agricultural community is not ready to accept PNR as a practice to recommend on a routine basis. Despite this fact, PNR appears a cost-effective nitrogen load reduction strategy on a substantial number of high loading acres in comparison to other options.

PNR should be considered as a viable option for implementation on the acres most at risk of N loss in watersheds where other nitrogen reduction practices may not be sufficient to meet load caps. In addition, farmers will be more interested in further experimentation with PNR when nitrogen trading markets are sufficiently robust and credit prices rise. .

A far more effective and palatable approach for farmers is to promote aggressively the adoption of nutrient use efficiency using numerous tools from the very basic (splitting application of nitrogen, crediting manure) to high tech advances such as variable rate applications. It is important to separate the Performance Guarantee System of the BMPC from the specific practice of planned nitrogen reduction that was the main effort of the last several years.

2) **Nutrient Management BMP Challenge (Nutrient BMP CHALLENGE)**—reducing nitrogen loading by applying fertilizer at rates equal to the land grant university recommendations.

Findings:

a) **Nutrient BMP CHALLENGE reduced nitrogen use and nitrogen loadings:** Participants in Nutrient BMP CHALLENGE in demonstrations across the country reduced N application rates by an average rate of 20%, averaging 37.4 pounds per acre, to get to Land Grant University-recommended rates. This translates to a total of 180,400 pounds nitrogen use reductions and; if all of the acres were within the Bay watershed, total N-load reductions delivered to the Chesapeake Bay of 52,300 pounds.

b) **But farmers on average saw reduced yields and negative net returns:** These reductions resulted in an overall average loss of 4% equaling 6.7 bushels (bu.) per acre, which translates to an average loss of $4.86 per acre based on the net return to nitrogen calculation used based on yield, corn price and nitrogen price.

c) **However, over 60% of farmers broke even or had positive net returns:** While the average experience per acre was negative, the net returns varied considerably between fields and across the years: Of the 99 fields enrolled in the Nutrient BMP CHALLENGE through 2010, 61 showed no losses and 42 experienced positive net returns. Experience on fields where producers split their applications of nitrogen or implemented greater precision in rate, timing and placement of nutrients indicate that more positive results are achievable.

d) **Nutrient BMP CHALLENGE is cost effective compared with other conservation practices:** Even using the average negative net returns, when comparing the cost of reducing nitrogen losses, the Nutrient BMP CHALLENGE is highly competitive with other practices. Cover crops, a popular practice being promoted in the Chesapeake Bay region to achieve nutrient reductions, cost $7.34 per pound based on state and federal cost-share payments. This compares to $4.14 per pound in the Nutrient BMP CHALLENGE, a 43% difference. Unlike cover crops that may require additional annual investment by the farmer for seed and planting costs, most Nutrient BMP CHALLENGE farmers reported a reduction of N application rates on a majority of their acres after one year of participation without additional assistance. Eighty-eight percent of respondents to a 2011 survey said they were continuing or planning to continue the new practice (or modified form of the practice) after their experience. Participants also indicated that they intended to implement the practice on an average of 50% of their acreage after a single year of participation

e) **LGU recommendations close to optimum economic returns to N:** Given the uncertainty inherent in determining optimum N rates, the LGU recommendations followed by BMP Challenge participating farmers were surprisingly close to generating optimum economic returns to N. Many farmers suggested that the negative impact on yields could be due to university recommendation possibly not keeping pace with the new improved plant genetics requiring additional N.

Recommendation

Based on these experiences, Nutrient BMP CHALLENGE represents an opportunity to significantly reduce N loadings into the Bay in a proven, cost effective way that allows farmers to gain experience with nutrient management and then apply it to additional acreage.

Assuming Pennsylvania producers apply nitrogen at similar rates and experience similar results to those found nationally, it is possible that a one-time investment of $6 million in scaling up the Nutrient BMP CHALLENGE to address 104,000 acres (25% of the 417,000 Pennsylvania corn acres that are at highest risk for N losses) would result in a direct reduction of 1.13 million pounds of N load to the Chesapeake Bay. In addition, assuming the farmers expand the practice to additional acres similar to those reported on survey results, reductions of 2.67 million pounds, or 15.4% of Pennsylvania's Watershed Implementation Plan goal, could be achieved in subsequent years for the nominal cost of updating nutrient management plans on an annual basis.

To realize this potential, a new effort is needed to apply the Nutrient BMP CHALLENGE to increase the adoption of Pennsylvania State University's recommendations in key corn-producing regions that are most at risk of N losses. This effort should focus on accelerating the adoption of the range of practices that Penn State is recommending to increase nitrogen use efficiency and that can facilitate producers coming into compliance with state requirements under the Clean Stream and other laws. On one hand, they include basic practices such as split N applications, with the second application applied as sidedress, using PSNT or chlorophyll meter readings and full crediting of manure N values. On the other hand they include new technology, such as active sensors with the potential to more accurately distribute sidedress N based on need within specific areas of the field. The BMP CHALLENGE could support all such practices. If long-term adoption rates are consistent with those experienced to date, an up-front investment of less than $6 million could deliver nearly 20% of Pennsylvania's commitment to N-load reductions on a sustained basis at no additional cost. These advanced technologies are likely to improve efficiencies in contrast to those experienced to date by further reducing yield and nutrient losses and thus, costs per acre and per pound of N-load reductions. This investment could be made over several years.

Support from partners to the Growing Greener grant activities, including the Chesapeake Bay Congressional Delegation and departments of Agriculture and Environmental Protection, needs to be encouraged to help advance the guarantee system approach. Support for specific language in the next Farm Bill, or other vehicles, could direct the NRCS to offer the BMP CHALLENGE as an option for farmers. The Farm Bill programs administered by NRCS are the largest near-term source of funding available for the guarantee system. Thus, the Nutrient BMP CHALLENGE is an ideal adoption support tool consistent with NRCS EQIP limited-term contracts.

3. **Achieving cost reductions for BMP CHALLENGE—**the BMP CHALLENGE program and the conservation practices have the potential to achieve meaningful cost reductions as suggested by the Project Advisory committee.

Findings:

a) **Scaling up will reduce costs:** The current project data involved demonstrations on fairly small acreages (12-150 ac). A scaled up effort that covered more acres on a farm would help improve cost effectiveness. Field size impacts costs per acre and costs per pound of N-loss reduction in cases where consultants are paid a flat fee per field. (This arrangement has been the case in the Mid Atlantic BMPC demonstrations. In other states, and in NRCS programs, payments are made on a per acre basis.) Most consultant costs, e.g., time, travel, and setting up the comparison strips are independent of field size. If consultants are paid an average of $1200 per field, costs of N-loss reduction for PNR differ by $4.74 between a 25 and a 100-acre field, a difference of 23%. For Nutrient BMP CHALLENGE, the difference is $2.96, a difference of 41%.

   In Maryland in the last three years, more than one practice demonstration was implemented on the same farm, further reducing cost given the fixed costs associated with travel and travel time to the farm.

b) **Increased use of advanced nutrient management techniques will reduce costs:** Greater precision in achieving nitrogen reductions has the greatest potential to reduce costs of the BMP

CHALLENGE since over all reductions in N-loss can be achieved while maintaining, or even increasing yields and thus decreasing pay outs.

i) Producers who applied commercial N in more than one application (e.g., at or prior to planting, and a second application in late spring) experienced greater yields (and net returns) than for producers who made a single application.

ii) Demonstrations with vertical tillage incorporation of dairy and poultry manure (that reduces N volatilization) in Maryland had higher yields than comparison plots where the manure was surface applied.

c) **Corn prices most important cost factor:** Fluctuations in corn prices were the most important factor affecting costs and ranged from a low of $2.20 per bushel in 2006 to a high of $4.75 in 2008, in contrast to the price of $6.01 in early 2011. For the PNR fields, each dollar increase in corn price increase overall program costs by approximately $16 per acre and $1 per lb. of N-loss reduction. This impact dwarfs other cost efficiency measures tried during the project such as reducing cost share rates.

Recommendations

There is considerable room to increase the cost efficiency of operating the BMP CHALLENGE both through refining program elements such as field size, consultant compensation and targeting practices that focus on nutrient use efficiency. The optimal situation for this program is to identify producers whose fear of potential yield impact is holding them back from adopting a practice that has a strong track record of effectiveness (e.g., split applications, in season testing, different tillage methods). Using the guarantee tool to offer a risk-free trial of a low-risk practice is likely to achieve a high level of adoption at a minimal cost. However, changes in corn price will continue to have the significant impacts on overall program costs.

As stated above, BMP CHALLENGE should target to aggressively promote the adoption of nutrient use efficiency practice to achieve optimum cost effectiveness. In addition two approaches that show additional potential for lowering costs should be given greater attention in the future are:

- Targeting fields with high levels of residual nitrogen on the assumption that such fields would show less response to the reductions, and
- Targeting fields with droughty/sandy soils where the lack of moisture likely affected yields more frequently than nutrient levels, could generate equivalent economic returns with less fertilizer.

4. Program Mechanics of BMP CHALLENGE—effectiveness of the BMPC program design

Findings:

a) **Single check strip protocol cost effective and consistent with others:** The yield results collected from the BMP Challenge program, which uses a single check strip protocol, are consistent with those from the concurrent Iowa On-Farm Network® and Minnesota Nutrient Management Initiatives, which used multiple rather than single-check strips. The multiple check strips are more costly and are not required in order to get representative and repeatable results, or to increase farmer adoption of better practices. In a survey of 37 BMPC participants from 2003-2010, all but one reported being "satisfied that the method used to determine net returns and calculate guarantee payments was accurate and fair."

b) **Farmers like the BMP CHALLENGE:** According to the surveys of past nutrient management and conservation tillage participants completed in 2011, 89% of respondents were satisfied with the income protection provided under these programs.

c) **Added benefits include technical assistance and adaptive management:** In addition to providing an effective tool to address risk concerns of producers to adopt new practices, the BMP CHALLENGE addresses the critical needs for 1) technical assistance to producers and 2) participation in an adaptive management process, by building in the participation of a certified crop consultant as part and parcel of the delivery system. Annual and past participant surveys indicate that "educational value" has been "very important." The PA Conservation Commission's Nutrient management program director has indicated that the inclusion of technical assistance as part of the program design is highly valuable in getting farmers to work through their nutrient management plans with assistance from a qualified professional.

d) **Program delivery and administration works well:** The administrative and program delivery mechanism that Agflex, AFT and field partners have developed compares favorably to systems that USDA (NRCS) and crop insurance providers use to offer their products. Agflex targets payments to farmers with opportunities for improving practices, verifies implementation, documents outcomes, including impacts on yields, net income and natural resources, and compensates only those farmers who suffer net economic losses and only for the amount of actual loss.

Recommendation

BMP CHALLENGE mechanics are attractive to producers and crop advisors, result in high conversion rates to new practices, provide critical technical support and verification, and are delivered cost effectively. So the basics of BMP CHALLENGE mechanics should be maintained moving forward with minor modifications. These should be maintained with ongoing R&D for continuous improvement and addition of new practices. Additional improvements should include upgrading data collection to include site-specific rainfall amounts, timing and intensity; yield history; soil type and slope; and topographic and location factors needed to allow more extensive data analysis and more precise calculation of N-load reductions. Surveys of past participants should also be improved to increase sample size and accuracy.

Additional investments should be made to identify cost-effective practices that still suffer low adoption due to lack of technical support and income protection, including livestock nutrition management and cover crops, and to support continuous improvement of the system developed in this pilot, including lower-cost yield and net income assessment systems. Further investment is also needed to collect baseline data on farmer adoption of BMPs in Pennsylvania.

1. Introduction

For decades, multiple indicators have documented the failure of Chesapeake Bay to meet its potential for water quality, seafood production and recreational uses because of its degradation by excessive nutrient and sediment levels. In 2009, Bay water quality was estimated at 24% of established goals and more than 50% of streams in the watershed were rated as either poor or very poor.[2] Nitrogen (N) loading represents the most critical impairment, currently estimated at 160% of acceptable levels, followed by phosphorus (P) at 150%.[3]

Elevated levels of N are accelerating the growth of algae and other aquatic plants, which in turn blocks sunlight and reduces oxygen required by fish, blue crabs and other aquatic organisms. N in sub-surface flows reaches the Bay through drainage ditches, drainage tile and natural routes of groundwater return. Between 1999 and 2001, nitrate levels exceeding the federal standard for drinking water of 10 mg/L were found in one-third of 29 private domestic water wells and in one sample of 30 wells from an aquifer used for public water supplies in the Delmarva Peninsula.[4] The federal standard for drinking water is set to prevent restricted oxygen transport in human blood that can result in death, especially for infants younger than four months old who lack the enzyme that corrects this condition. Agriculture is the leading source of nutrients and sediments in surface water and nitrate concentrations in groundwater are highest from wells sampled in agricultural areas.[5]

Federal and state governments are accelerating efforts to remove Bay impairments by 2025. Agriculture has been a major contributor to progress to date and continues to have a critical role as the single largest user of clean water, the leading source of nutrients and sediment, and a key component of the

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[2] Federal Leadership Committee for the Chesapeake Bay. 2010. *Fiscal Year 2011 Action Plan: Executive Order 13508*. 99 pp. http://executiveorder.chesapeakebay.net/file.axd?file=2010%2f9%2fChesapeake+EO+Action+Plan+FY2011.pdf
[3] Chesapeake Bay Foundation. 2010. State of the Bay 2010. 20 pp. http://www.cbf.org/Document.Doc?id=596
[4] Denver, J.M., S.W. Ator, L.M. Debrewer, M.J. Ferrari, J.R. Barbaro, T.C. Hancock, M.J. Brayton and M.R. Nardi. 2004. *Water Quality in the Delmarva Peninsula, Delaware, Maryland, and Virginia, 1999-2001*. US Geological Survey, Circular 1228. 40 pp. http://pubs.usgs.gov/circ/2004/1228/pdf/circular1228.pdf
[5] Mueller, D.K., and D.R. Hensel. 1995. *Nutrients in the Nation's Waters: Too Much of a Good Thing?* USGS Circular 1136.d

region's economy, ecology and landscape diversity. Best Management Practices (BMPs) have potential to meet and exceed agriculture's designated improvements, but are not universally adopted due to lack of information, technical support and economic risk to farmers.

In this document, we report on results of a pilot designed to provide technical support, net income protection and verification of practices and outcomes to reduce nitrogen losses from croplands. To date, the pilot has delivered N-use reductions exceeding 424,000 lbs. on nearly 14,000 acres.

WATERSHED WATER QUALITY

The Chesapeake Bay Watershed encompasses 64,000 square miles and includes parts of six states and the District of Columbia, stretching 200 miles from Cooperstown, New York to Norfolk, Virginia. The watershed is approximately 16 times the size of the Bay itself, the largest ratio of any similar watershed in the world. The sheer size of this area imposes a daunting management challenge in terms of effectively overseeing the wide array of practices performed across the landscape that affect the Bay's water quality.

Water quality in the Bay has been a major concern for decades, making headlines and generating support for dramatic action to restore this national treasure and economic engine. In 2009, President Obama signed an Executive Order recognizing the national significance of the Chesapeake Bay and requiring federal agencies to improve research and better target resources to restore water quality in the Bay.

In 2010, the U.S. Environmental Protection Agency (EPA) established a Total Maximum Daily Load (TMDL) for the Bay setting load allocations for N, phosphorus and sediment from point and non-point sources, including agriculture. The Bay's TMDL is the largest and most complex of more than 40,000 established nationally, setting limits that represent a 25% reduction in N, a 24% reduction in phosphorous (P), and a 20% reduction in sediment reaching the Bay. It is designed to remove the current impairments by 2025. The Bay's TMDL supplements local load settings that are already in place.

AGRICULTURE'S ROLE AND RESPONSIBILITY

Agriculture represents 30% of the land uses in the watershed, including cultivated cropland (10%) and pasture/hay crops (18%). In addition to food production, agriculture provides employment, landscape diversity, biofuel production, and important ecosystem services like carbon sequestration and wildlife habitat. Nutrients including N and P are also essential for agricultural productivity, including plant growth and livestock health. Agriculture is the largest source of nutrients in the Chesapeake Bay and in surface water nationally, as well as the largest user of clean water for irrigation and other needs.

Manure on agricultural lands contributes an estimated 18% of the N delivered to the Bay. Chemical fertilizers used in agriculture contribute an additional 18%. Estimates for additional sources of N delivered to the Chesapeake include emissions from fossil fuel combustion from vehicles, industry, electric power generation (33%), wastewater treatment facility discharges (19%), household septic systems (4%) and urban/suburban runoff.[6]

The 2011 report from the Chesapeake Bay Conservation Effects Assessment Program (CEAP) on cropland indicates the watershed is facing unique challenges compared to the Upper Mississippi River Basin, including higher annual precipitation, higher average slopes, and a higher percentage of moderate-to-high leaching potential, more highly erodible land and more acres with manure applications.[7] Cropland represents only 10% of the land area in the watershed but contributes an estimated 31% of N to surface water. Pasture and hayland contributes an additional 12%. Nearly all cropland in Pennsylvania is categorized as moderate to high in soil runoff and leaching potential.

An extensive list of on-farm practices has been developed with potential to reduce nutrient and sediment losses. Permanent and semi-permanent structural practices include stream bank and ditch stabilization and reconstruction, terraces, manure storage, and forest and other buffers. Examples of seasonal practices include cover crops, reduced tillage and nutrient management including right timing, product, placement and rate.

Agricultural BMP Adoption Fails to Reach Potential

While the Chesapeake CEAP report estimates substantial progress in reducing N losses since the 2003 to 2006 baseline, these improvements are not evident in improved water quality and BMP adoption remains far below potential. Only 13% of cropland acres receive optimum N management practices for all crops every year, with acres receiving manure having the greatest potential for improvement. Additional potential for improvement on the poorest performing 810,000 acres of cropland includes reducing nitrogen losses with surface runoff by 27% and with subsurface flows by 20%. These acres, representing 19% of the total cropland in the watershed, currently have the least amount of conservation treatments and the highest losses. To achieve additional N-loss reductions, the report calls for increased cover crops and comprehensive nutrient management to address appropriate rate, form, timing and method of application.

Low adoption of proven practices is not unique to the Chesapeake Region. According to a 2009 CTIC/Fertilizer Institute survey, nearly one-half of farmers do not follow university recommendations for testing soil for nutrients, a basic practice.[8] American Farmland Trust (AFT) and Agflex's2005 survey, with 700 corn-grower respondents, found that 14% do not credit N contribution from soybeans and 25% do not credit contributions from manure. Only 12% reported using late-spring N testing and application, a practice with potential to reduce nitrogen losses by 25% to 50%. Eighty percent of respondents indicated they would reduce fertilizer rates if their incomes were protected

[6] Chesapeake Bay Program. Undated. *Nitrogen.* http://www.chesapeakebay.net/nitrogen.aspx?menuitem=19412
[7] USDA Natural Resources Conservation Service. 2011. *Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Chesapeake Bay Region.* 158 pp.
[8] 2009. *Conservation Technology Information Center and The Fertilizer Institute Survey Farmers' Conservation Activities*, IN. From a press release. http://www.tfi.org/mediacenter/2009/pr072009.pdf

More than 20 studies over the past 40 years have identified lack of information and technical assistance, additional time, and either real or perceived risk to income as key barriers to BMP adoption by farmers. For example, a USDA Economic Research Service (ERS) survey asked farmers why they have not adopted common BMPs. Respondents identified two factors: more labor-intensive work and fear of economic loss. Producers indicated an incentive payment of $70 per acre would be required to achieve a 50% adoption rate.[9] ERS researchers examining the risk of timing N applications closer to crop need estimated that risk-averse farmers would require $37 per acre to adopt the practice.[10] A recent survey conducted in the Upper Chester River Showcase Watershed in Maryland, and a second of Delaware producers with a certified nutrient management plan, asked respondents to identify their "top considerations when trying a new practice." Twenty-eight percent of the Upper Chester assessment identified "risk of yield loss."[11] Twenty-two percent of the Delaware sample identified the same issue.[12]

Without adequate assistance and risk protection, extra inputs are a rational defense against income loss. Heavy rains in spring and early summer can wash away nutrients before the crop takes them up. Bumper crop growing conditions can call for more nutrients than university recommendations provide.

N management is particularly challenging. A report by the National Academy of Sciences report concluded:

> *"Producers face a management dilemma because the effectiveness and efficiency of nitrogen management cannot be assessed, economically or environmentally, until the growing season is over. A crop that produces poor yields because of inclement weather will result in poor nitrogen use efficiency and uptake, nitrogen to be lost to the environment, no matter how carefully a management plan was designed. Since producers must make nitrogen applications without being able to predict weather and crop yields, the potential for being wrong is always present and will always occur in some years."*[13]

Other factors further complicating N management include inconsistent N-use efficiency across sites and years, a poor statistical relationship between the economically optimum N-rate and N-rate recommendations based on expected yield, a lack of precision in how yield goals are

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9 Cooper, J.C. and R.W. Keim. 1996. Incentive payments to encourage farmer adoption of water quality protection practices. *Amer. J. Agric. Econ.* 78(1): 54-64.

10 Huang, W., T.I. Hewitt and D. Shank. 1998. An analysis of on-farm costs of timing N applications to reduce N losses. *J. Agricultural and Resource Economics* 23:445-467.
Huang, W. 2002. Using insurance to enhance nitrogen fertilizer application timing to reduce nitrogen losses. *J. Agricultural and Applied Economics* 34:131-148.

11 Maryland Department of Agriculture, USDA Maryland Natural Resources Conservation Service, Kent Soil and Water Conservation District, Queen Anne's Soil and Water Conservation District and Maryland Department of Natural Resources Forestry Service. Undated. *Upper Chester River Showcase Watershed Project Farm Assessment Report.* 68 pp.

12 Delaware Conservation Partnership. Undated. *The Delaware Nutrient Management Survey: Summary and Results.* 54 pp.

13 National Research Council, Committee on Long-Range Soil and Water Conservation Policy. 1993. *Soil and Water Quality: An Agenda for Agriculture.* National Academy of Sciences. 542 pp.

determined, and uncertainty about N contributions from non-fertilizer sources.[14] In several states, Land-Grant universities (LGUs) have recently revised N-rate recommendations that have been in place for thirty years or more. These changes are designed to address shortcomings in yield-goal-based recommendation systems, where farmers estimate yield from past history, select an N rate based on the yield estimate, and then discount that rate based on estimated contributions from prior legume crops and/or manure applications.

PSU recommendations are based on yield goals with manure and legume crediting. Separate recommendations are made for corn for grain and corn for silage. The recommendations also call for applying N as close to plant utilization as possible, including split applications, and recognize that actual N need "varies with the yield potential of a site and the many other factors that affect N availability and N use by the plant."[15]

Pennsylvania's Progress and Potential

Pennsylvania's major basins discharging into the Chesapeake include the Susquehanna, Potomac and Gunpowder Rivers, and the Northeast and Elk Creeks. In preparation for the Chesapeake TMDL, the Pennsylvania Department of Environmental Protection completed a Phase I Chesapeake Watershed Implementation Plan that divided allocations by major basin and source sector. US EPA provided updated allocations in August 2011. Phase II plans were required from Bay states by December 2010, which further sub-divide source loads by county.

According to US EPA, from 1985 to 2009, Pennsylvania achieved 28% of the N reductions required to meet its allocation, as well as 46% of the P and 38% to 46% of the sediment. Pennsylvania has been a leader in the watershed, establishing the largest Conservation Resource Enhancement Program in the nation to support edge-of-stream BMPs and exceeding its 2010 goal for forest buffers along waterways and permanently preserving more than three million acres of land in the Watershed.

Pennsylvania farmers have contributed to this leadership position through their participation in the first mandated programs for nutrient management plans and EPA-approved mandates for concentrated animal feeding operations. **Agriculture, while accounting for 56% of Pennsylvania's N loading, has been responsible for 80% of N load reductions. Pennsylvania farmers have been responsible for 41% of all the N reductions from agriculture in the entire watershed, as per US EPA's 2010 calculations.**

Pennsylvania's strategy to reach its allocations includes implementing and tracking milestones, supporting adoption of advanced technologies and nutrient trading, and enhancing common-sense compliance efforts. An additional 29.5 million lbs. of N must be achieved by 2025.

[14] Sawyer, J., E. Nafziger, G. Randall, L. Bundy, G. Rehm and B. Joern. 2006. *Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn.* 28 pp. http://www.extension.iastate.edu/publications/pm2015.pdf

[15] Beegle, D.B. and P.T. Durst. 2011. *Nitrogen Fertilization of Corn.* Agronomy Facts 12. http://cropsoil.psu.edu/extension/facts/agronomy-facts-12

Tracking and reporting all BMPs, including privately funded BMPs, cover crops and reduced tillage will be a major task. A non-point BMP data repository has been developed, and BMP tracking pilots are underway in two counties. Advanced technologies include energy and soil amendments produced from manure and other farm-generated materials.

Support for trading includes establishment of a clearinghouse for transactions in the Pennsylvania Infrastructure Investment Authority (PENNVEST) and regulations (published in 2010) that require nutrient reductions to exceed regulatory mandates to be eligible for trading and caps on the total tradable credits from nonpoint sources.[16] Nine contracts have been signed to date, with eight more pending execution.

Compliance components include continuing existing Controlled Animal Feeding Operations (CAFO) and cropland nutrient management mandates, evaluating and modifying regulatory and administrative tools, expanding outreach and technical assistance to increase compliance, and targeting specific impaired watersheds with individual farm assessments to identify opportunities for improvement. Every agricultural operation that stores, handles or applies manure must have a manure management plan, and all operations with two or more animal-equivalent units per acre must have a nutrient management plan compliant with Pennsylvania Act 38.

As of 2010, Pennsylvania's Nutrient Management Program has approved 1036 plans for regulated animal operations and an additional 1735 non-mandated animal operations.[17] This total of 2771 approved plans compares to a total o f 63,163 farms in Pennsylvania in 2007, including 8407 dairy farms and 15,771 grain-producing farms.[18] Data are lacking regarding how many additional farms have nutrient management plans that have not been submitted for approval.

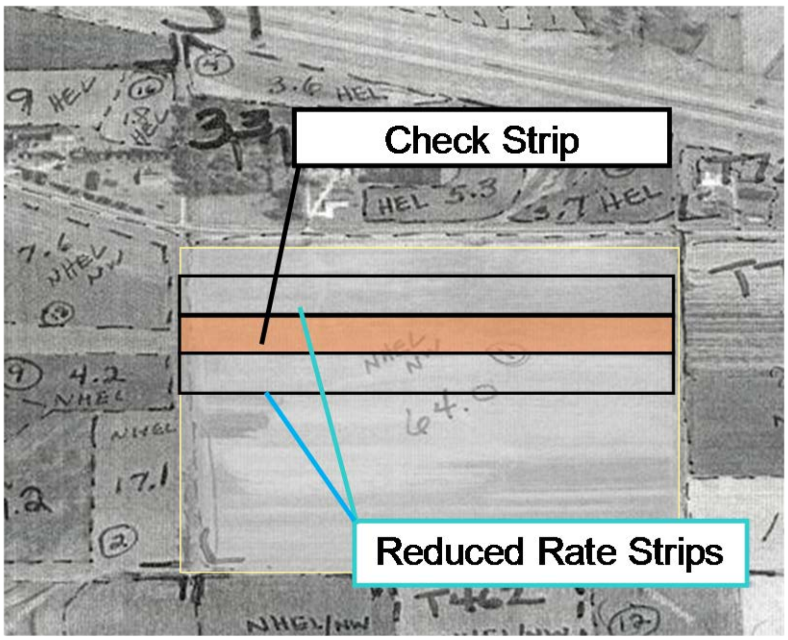
Nitrogen Management Performance Guarantees: An Opportunity

With participation and support from more than 110 producers and multiple partners and funders, AFT and Agflex have piloted an innovative system that provides technical and financial assistance to farmers who implement basic to advanced strategies to reduce N losses. The system addresses the key barriers to BMP adoption and has also been used to reduce P and sediment losses.

The system employs a crop advisor to develop the N management plan, carefully place a check strip in a representative area of the farmer's field (Figure 1) and assess yield at harvest. The harvest assessment compares yield on the check strip, which is fertilized using the farmer's traditional practice, with the yield on the immediately adjacent strips fertilized at or below university-recommended rates for N.

[16] 2010. Water Quality Standards Implementation. Section 96.8, Chapter 96, 25 Pa. Code.
[17] Pennsylvania Department of Environmental Protection. 2011. *Pennsylvania Chesapeake Watershed Implementation Plan.* 280 pp. http://www.lccwc.com/pdf/revised_final_pa_chesapeake_bay_wip-jan-2011.pdf
[18] USDA NASS. 2007. State Level Data, Pennsylvania. *Census of Agriculture* 1(1). http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Pennsylvania/index.asp

Figure 1. Map of Planned N Reduction (PNR) field showing placement of the check strip, receiving the BMP rate of nitrogen calculated using Pennsylvania State University recommendations. The balance of the field receives the reduced rate, e.g., 15% less nitrogen. At harvest, the yield from the check strip is compared to the average yield of the two immediately adjacent strips to minimize impacts of within-field variability. Comparison strips are carefully placed in a representative area of the field by a qualified crop advisor, avoiding wet spots or other non-representative areas.



Agflex finalizes a net returns assessment for each field, incorporating any savings in N costs, and compensates the farmer for any shortfall. Crop advisors are compensated for their involvement. Farmers who apply nitrogen at rates less than those recommended by their state university (i.e., BMP rates) also receive a payment to compensate them for the time they invest in their participation.

This approach is compatible with the science of behavior change and adaptive management, including trialability and observability by participating farmers. They can see the practice perform over their own fields, and have access to expert assistance with quantitative verification of impacts on yields and net income. Farmers can then continue to use that practice on additional acres or adapt the practice to fit the conditions on their farm/s.

Here we report on results of pilots on more than 16,000 acres in Pennsylvania and other states, and on the feasibility of the N performance guarantee system to contribute to Pennsylvania's commitment to further reductions.

Our approach supports Pennsylvania's strategy, including providing efficient mechanics and verification for water quality credit trading for nutrients and expanding outreach and technical assistance, especially for acres identified as lacking proven BMPs.

2. Goals and Objectives

The goal of this study is to evaluate the potential of a nitrogen management performance guarantee system to demonstrate and help fulfill Pennsylvania's commitment to improving water quality in Chesapeake Bay. To that end, we have analyzed and reported on results obtained from eleven years of field trials of the guarantee system for nutrient management, conservation tillage and planned N reduction in corn grown for grain or silage.

Specific objectives include:

1. Analyze results to date, including N-use and load reductions and costs. Assess impacts of key variables including manure versus commercial N, corn grown for grain versus silage, and site-specific elements including location, soil type and topography.

2. Based on results to date, project potential N load reductions and costs if implemented on a larger scale, including identifying practices and acres to be targeted to gain the greatest efficiency.

3. Identify the most cost-effective options for implementation of key roles and responsibilities, including farmer recruitment, technical assistance, net-income determination, farmer compensation, overall program administration and oversight, ongoing research and development, and education and outreach.

4. Incorporate additional analysis to address complicating and related factors:
    a. What amount of manure might be displaced by reductions in applications being made currently? What are the best alternative uses for this manure?
    b. How many additional acres of corn production would be required to replace yield shortfalls generated?
    c. How might water quality credit trading contribute to cost efficiencies?
    d. What is the potential to apply the system to other BMPs?

3. Implementation Methods

The guarantee system has been used primarily for PNR, nutrient management and conservation tillage in corn grown for grain or silage. PNR, also historically referred to as enhanced nutrient management[19] and yield reserve,[20] is an approach to achieving water quality objectives whereby farmers apply N at **less than** LGU-recommended rates. PNR is designed for potential ongoing farmer participation in watersheds where nutrient impairments would remain, even if all farmers followed LGU recommendations. Farmers are provided with a cost share payment in addition to the net income guarantee. Thus, PNR incurs ongoing costs to maintain N use, loss and load reductions.

Since 2004, the nutrient management and conservation tillage programs have been marketed as Nutrient BMP CHALLENGE® and Reduced Tillage BMP CHALLENGE®, respectively. These two systems support participants who follow LGU recommendations for fertilizer application rates and tillage systems that maintain at least 30% residue cover. In contrast to PNR, these guarantee programs do not provide a farmer cost share and are intended for short-term participation, typically on one or two fields, until the farmer is comfortable with the BMP. The majority of participants adopt BMPs to at least some degree on a majority of their acreage after one year of participation.

Participant recruiting. American Farmland Trust and Agflex were the principal recruiters for this pilot. Recruiting has been accomplished through brochure mailings, e-mail campaigns, webinars, press releases, presentations at meetings, and personal contacts. These efforts targeted key influencers of farmers, including crop advisors and conservation professionals who have good personal relationships with farmers and who are ideally suited to present this potential opportunity. TeamAg, a crop consulting firm based in Ephrata, Pennsylvania, has been the primary recruiter of farmers for PNR in Pennsylvania, where the majority of the 9000 acres were implemented.

Technical assistance and verification. Crop advisors must be Certified Crop Advisors, state-certified or have equivalent experience to ensure competent implementation. The crop advisor develops the plan for the new practice to be used. Crop advisor assistance for nutrient management and PNR addresses product form, rate, timing and placement. For conservation tillage, assistance includes reduced tillage system selection, equipment set up and additional visits during the season to assess weed and irrigation management and adjust as needed.

[19] Chesapeake Bay Commission. 2004. *Cost-effective Strategies for the Bay: Smart Investments for Nutrient and Sediment Reduction.* Annapolis, MD. 13 pp. http://www.chesbay.state.va.us/Publications/cost%20effective.pdf

[20] Clancy, K., E. Higgins and L. Obeholtzer. 2001. *Making Changes: Turning Local Visions into National Solutions: Agriculture and Rural Development Policy Recommendations from the Agriculture Policy Project.* Henry A. Wallace Center for Agricultural & Environmental Policy at Winrock International, Arlington, VA. 86 pp. http://www.winrock.org/agriculture/files/makingchanges.pdf

To estimate the impact of the new practice, crop advisors carefully place a control or "check" strip within a representative area of the field following a written protocol.[21] Participating farmers implement their traditional practice on the check strip. A single check strip is used to reduce time, expense and management complications for producers.

The crop advisor also supervises harvest. Yields and input costs from the check strips and immediately adjacent strips are compared. Immediately adjacent strips, rather than the balance of the field, are used for comparison to minimize within-field variability. An in-depth analysis of the check strip approach[22] was reviewed by multiple independent experts and approved by the Federal Crop Insurance Corporation Board[23] prior to initiation of the project. The analysis concluded that yields on the immediately adjacent strips are highly correlated at 90% or higher. In other words, nine times out of ten, one can expect the yields to be within 5% on immediately adjacent strips placed at random within the field. The team's written strip placement protocol is designed to improve upon that correlation by directing the crop advisor to locate the strips in a uniform, representative area of the field. Our results are strikingly similar in averages and ranges to results obtained from replicated strip trials in multiple states.

Crop advisor roles include submitting participant data, including an enrollment form, check-strip information form and net-returns-assessment forms. Data collected includes information on the location, practice implemented, check strip and harvest assessment.

In most instances, crop advisors have been independent consulting professionals. Others who have filled this role include conservation district professionals, Extension agents, university researchers, state agency staff or crop advisors employed by an ag retailer.

Farmer payments. Farmers are compensated by Agflex for any net income loss, taking into consideration savings from the new practice. Agflex is a for-profit corporation formed in 2000 specifically to administer payments to farmers and maintain sufficient reserves to do so. Agflex charges a flat per-acre fee to funders for each practice. The fee is determined by updating farmer payment history to reflect current corn prices and adding a 30% administration fee plus a 5% contribution to reserves.

Administrative costs include processing farmer and crop advisor enrollment, collection of nutrient management plan, fertilizer cost, check strip and yield data, processing payments to farmers and crop advisors, and maintaining forms for enrollment and participant data collection. They do not include outreach to and recruitment of conservationist, crop advisor and farmers, program development, data analysis, or grant management including financial and other performance reporting.

[21] 2011. Nutrient BMP CHALLENGE 2011Check Strip Information Form. Agflex. 2 pp. http://www.bmpchallenge.org/Nutrient%20BMP%20CHALLENGE%20Check%20Strip%20Form%202011%202.21.2011.pdf
[22] Mitchell, P. 2002. Rating Methodology for the Nutrient BMP Insurance Policy. 29 pp.
[23] USDA RMA. 2003. Nutrient BMP Endorsement for CRC Policy. http://www.rma.usda.gov/policies/2003/n-bmp/pdf/crc_bmp_endorsement.pdf

Operating costs include recruiting, payments to crop advisors for their services and the Agflex fee that includes payments to farmers who suffer lost net income as a result of the practice. Research and development costs are not included in analyses here.

CURRENT PROGRAMS OFFERED

In addition to results reported here, in 2010 we enrolled four fields testing P applied at university-recommended rates and one testing potassium rates. An additional seven fields were enrolled for testing a manure incorporation practice designed to increase N-use efficiency and reduce losses. We are currently offering the guarantee system for the following practices:

"Training" guarantees, designed for short-term participation on one or two fields, followed by long-term adoption on the majority of a farmer's acreage:

- Reduced tillage. Any variation that retains at least 30% residue including no till, strip till, ridge till.
- Basic nutrient management, e.g., crediting legume, manure N contribution, use of N-rate calculator incorporating N cost and corn price in rate calculation.
- Advanced nutrient management. Full implementation of complete plan to manage amount, source, placement, and timing of nutrients.
- In-season, post-season tests including pre-sidedress or late spring N test (PSNT, LSNT), corn stalk nitrate test (CSNT), chlorophyll meter testing to determine N rate for side-dress or other applications.
- Minimum disturbance incorporation of manure or commercial fertilizer.
- Manure or commercial fertilizer injection.
- Sensor-based variable rate application. Sidedress rate determined at time of application with variable rate equipment, e.g., GreenSeeker.

Ongoing guarantee and cost share required for continued adoption:

- Planned N Reduction, where farmers apply less-than-agronomic rates of N to improve water quality by reducing N losses to ground and surface water.

4. Results

Overview

This project has provided technical assistance and net income protection to more than 150 corn producers on 241 fields and 16,201 acres in 12 states. Participants have reduced N application by nearly 425,000 lbs. and prevented losses of more than 3400 tons of sediment and 4600 lbs. of phosphorus (Table 1).

According to surveys of past nutrient management and conservation tillage participants completed this year, 89% of respondents were satisfied with the income protection provided. Eighty-eight percent have continued or plan to continue the new practice or a modified form of the practice after their experience. Participants indicated they intend to implement the practice on an average of 50% of their acreage after a single year of participation.

Table 1. Summary of results for Planned N Reduction (PNR, n=100 fields), Nutrient BMP CHALLENGE (n=99 fields) and Reduced Tillage BMP CHALLENGE (n=42 fields) in corn grown for grain or silage through 2010. Reducing N fertilizer use reduces release of N_2O and also cuts CO_2 emissions during the production of N fertilizer. We used flat rate formulae to estimate sediment reduction (1.5 tons per acre), P loss reduction (2 lbs. per acre) and CO_2 reduction (0.5 lbs. per acre).

2000-2010 RESULTS	Planned Nitrogen Reduction	Nutrient BMP CHALLENGE®	Reduced Tillage BMP CHALLENGE®	Totals
Total acres, 2000-2010	9069 acres	4819 acres	2313 acres	16,201 acres
BMP yield, average and range	150.5 bu/acre 55.7-229.4	160.3 bu/acre 56.3-237.0	155.7 bu/acre 31.9-237.0	
Check-strip yield, average and range	162.4 bu/acre 63.1-264.0	167.0 bu/acre 49.8-230.0	165.1 bu/acre 26.2-242.0	
Average farmer net returns after fertilizer or tillage savings	($35.29) ($330.00)-105.24	($4.86) ($89.85)-$109.50	($13.48) ($156.77)-$130.20	
Total N use reduction	244,199.1 lbs	180,397.9 lbs	-	424,597.0 lbs
Estimated sediment reduction	-	-	3469.2 tons	3469.2 tons
Estimated P load reduction	-	-	4625.6 lbs	4625.6 lbs
Estimated N_2O reduction	4604.9 lbs	3401.8 lbs	-	8006.7 lbs
Estimated CO_2 reduction	681.5 lbs	503.5 lbs	1156.4 lbs	2341.4 lbs

On average, participating farmers experienced negative net returns when they implemented nutrient management or reduced tillage. In other words, input cost savings were not sufficient to overcome yield shortfalls. We anticipated reduced yields with PNR, which provides less N than universities recommend. Reduced tillage can result in a yield drag in colder climates, in seasons with cold, wet springs, or in the initial years when the farmer is working through the learning curve and soil structure is in transition.

We did not anticipate the yield reductions observed from LGU-recommended N application rates. We hypothesize these reductions may have resulted from older BMPs in need of updating. Most plans used a fixed pounds of N per bu. of expected yield established more than 30 years ago, e.g., 1.2 lbs. per expected bu., which have a number of limitations.[24] These recommendations may also fall short of economic optimum rates given higher N demands and yield potentials of current varieties including those with plant-incorporated-pesticides for corn rootworm. Most nutrient management plans used in our program, while typical of those in use by most producers, did not include advanced practices such as split applications, controlled-release formulations or calculations incorporating fertilizer costs or corn prices. In addition, growing conditions for corn during our project years were better than average; resulting in higher than average yields and potentially insufficient N to maximize yields in these years. Finally, higher corn prices result in a higher return to N, also not reflected in older nutrient BMPs.

Detailed statistical analysis was hampered by low sample sizes relative to the high variability of our data. Differences in weather from year to year, in tillage systems, soil types, application timing and N source all contributed to the high variability we observed.

The use of a single check strip does not appear to be factor in the results obtained here. Our results are comparable to those obtained from on-farm replicated strip trials conducted in Iowa between 2000 and 2007 (n>240), where farmers applied N at their normal rate and at 50 lbs. less than normal rate. In 2011, a minimum of four replicated strips and a GPS-equipped yield monitor were required.[25] Farmers were promised a payment to cover net income losses on a maximum of 10 acres, and a total cost-share payment of $200. They reported an average yield shortfall of 6.4 bu. per acre[26] compared to the 6.7 bu. per acre we obtained in 99 trials with an average 37.4 lb. of N reduction from normal rates.

Similarly, the Minnesota Department of Agriculture reported an average yield shortfall of 5 bu. per acre in 94 on-farm replicated-strip trials from 2006 through 2009 when N application rates were reduced 35.3 lbs. per acre on average vs. farmer normal rate.[27] Strikingly, this report indicated 61% of 94 farmers experienced a negative net return, vs. 65% of 99 here. In 2011, a minimum of three replicated strips were required per field and farmers were promised a payment of $1200 for participating.[28] These

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[24] Sawyer, J., E. Nafziger, G. Randall, L. Bundy, G. Rehm and B. Joern. 2006. *Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn.* 28 pp. http://www.extension.iastate.edu/publications/pm2015.pdf

[25] Iowa Soybean Association. 2011. *Iowa Soybean Association On-Farm Network® Normal Rate vs. Normal Rate Minus 50 ;bs. Replicated Strip Trial Protocol.* 1 pp. http://www.isafarmnet.com/2011OFNProtocols/2011NitrogenNormalRateNvsNormalRateMinus50lbs.pdf

[26] Iowa Soybean Association. 2008. 36 pp. 2007 On-Farm Network Agronomic Strip Trial Summary. http://www.isafarmnet.com/pdf/07summarysts.pdf

[27] Minnesota Dept. of Agriculture. 2010. Minnesota Nutrient Management Initiative: 2006-2009 Crop Years Economic Analysis. 44 pp. http://www.mda.state.mn.us/~/media/Files/protecting/nmi/2006-2009nmianalysis.ashx

[28]St. Ores, J. and B. Williams. 2011. *Minnesota Nutrient Management Initiative 2011 Crop Season Protocol.* USDA NRCS and Minnesota Dept. of Agriculture. 16 pp. http://www.mda.state.mn.us/~/media/Files/protecting/nmi/nminewprotocol.ashx

comparable results suggest that a single, carefully placed and immediately adjacent set of check strips per field is equally effective in producing replicable results.

PLANNED N REDUCTION

The PNR program used BMP CHALLENGE mechanics but participants reduced their N application rates further. These producers used a variety of BMPs including split applications, pre-sidedress N tests and corn-stalk N tests, but reduced the total N applied below the amount calculated by the crop consultant as consistent with LGU recommendations.

This pilot was developed in response to broad interest[29] in examining the impact of this practice on yields and net returns, to determine overall costs vs. benefits as a tool for improving water quality in N-impaired watersheds. This interest included comments from participants in a 2004 meeting in Pennsylvania to review the results of the Nutrient BMP Endorsement, a crop insurance product developed by American Farmland Trust and Agflex that preceded the guarantee system. The crop insurance product concept was not accepted by the crop insurance industry in part due to the unfamiliar agronomic aspects that made it challenging for many crop insurance agents to understand, market and implement. In addition, the endorsement required an up-front payment from farmers that made participation less attractive.

At that 2004 meeting, several individuals commented that they thought most farmers were already at university-recommended rates and that there may be some conservatism built into those recommendations, i.e., an “insurance” amount of fertilizer over and above agronomic requirements that would allow farmers to reduce applications further without impacts on yield. Based on these comments, we proposed a pilot project where farmers would be compensated for applying fertilizer below university recommendations and contributing to water quality. We also proposed to cover any yield losses using the guarantee system.

Through 2010, a total of 100 fields were enrolled (Table 2). Corn and N fertilizer prices varied considerably over the six years, ranging from \$0.23 to \$0.74 per lb. of N, and from \$2.20 to \$4.75 per bu. Overall averages were \$0.43 per lb. for N and \$3.36 per bu. for corn.

Actual N reductions ranged from 8% to 27% below LGU-recommended rates (Figure 2). Seventy-five fields received nitrogen application rates between 14 and 18% below BMP rates. Variability in application rates was in part intentional, i.e., some farmers chose a 10% reduction, and also due to

[29] Clancy, K., E. Higgins and L. Obeholtzer. 2001. *Making Changes: Turning Local Visions into National Solutions: Agriculture and Rural Development Policy Recommendations from the Agriculture Policy Project.* Henry A. Wallace Center for Agricultural & Environmental Policy at Winrock International, Arlington, VA. 86 pp. http://www.winrock.org/agriculture/files/makingchanges.pdf Chesapeake Bay Commission. 2004. *Cost-Effective Strategies for the Bay*. 13 pp. http://www.chesbay.state.va.us/Publications/cost%20effective.pdf
Metcalfe, T., D.J. Bosch and J.W. Pease. 2007. *Reducing Crop Nutrient Applications: The Yield Reserve Program.* Annual Meeting, American Agricultural Economics Association. Portland, OR. 31 pp.

uncertainties related to manure N value and consultant or farmer error in calculations or applications. We did not eliminate fields from our data set that did not receive the intended rate of application given that this variation is likely unavoidable and should be considered when estimating costs for scaling up the program beyond our pilot acres.

Average net returns were -$35.29 per acre (compared to -$4.86 for the Nutrient BMP CHALLENGE where farmers are applying at LGU-recommended rates), resulting in an average cost of $12.59 per lb. of N-loss reduction. Sixteen fields experienced a positive net return (Figure 3). Economic returns were calculated by adding fertilizer-cost reductions to the difference in value of the yield produced on the check strip vs. the immediately adjacent BMP strips. In other words, on average, fertilizer savings failed to make up for the yield deficit on the BMP portion of the field. The average acre lost 12 bu. versus the check strip, compared to 6.6 bu. for the Nutrient BMP CHALLENGE.

Table 2. PNR pilot participation by year; N and corn prices; estimated N loss, nitrous oxide (N_20) and carbon dioxide (CO_2) reductions, average net returns, farmer payments and cost of N-loss reduction, 2005 through 2010.

Year	No. fields	Total acres	Avg. price N ($/lb.)	Avg. price corn ($/bu.)	Total reduction in N applied (lbs.)	Average reduction N applied per field (lbs./acre)	Estimated total N loss reduction at 29% efficiency	Total N_2O reduction (lbs.)	Total CO_2 reduction (tons)	Average yield difference, BMP strip vs. check strip (bu.)	Average net economic returns per field ($/acre)	Average payout to farmer ($/acre)	Avg. cost N loss reduction ($/lb.)
2005	2	68.0	$ 0.23	$ 2.35	1,020.0	15.0	295.8	19.2	2.8	8.9	$ 24.05	$ 30.67	$ 26.56
2006	18	1687.6	$ 0.33	$ 2.20	45,720.8	26.4	13,259.0	862.2	127.6	(15.2)	$ (28.45)	$ 32.58	$ 11.45
2007	19	1944.4	$ 0.45	$ 3.50	52,738.7	27.7	15,294.2	994.5	147.2	(7.8)	$ (18.18)	$ 36.60	$ 11.96
2008	10	960.0	$ 0.63	$ 4.75	24,760.0	25.6	7,180.4	466.9	69.1	(9.2)	$ (31.29)	$ 29.59	$ 11.44
2009	25	2412.0	$ 0.74	$ 4.00	68,301.4	28.4	19,807.4	1,288.0	190.6	(15.3)	$ (56.55)	$ 49.24	$ 13.64
2010	26	1997.1	$ 0.53	$ 3.90	51,658.2	25.7	14,980.9	974.1	144.2	(11.9)	$ (38.21)	$ 36.15	$ 13.11
Avg./yr.	16.6667	1511.5	$ 0.49	$ 3.45	40,699.9	24.8	11,803.0	767.5	113.6	(8.4)	$ (24.77)	$ 35.81	$ 14.69
Avg./acre	-	-	$ 0.54	$ 3.60	-	26.9	7.8	0.5	0.1	(11.9)	$ (35.29)	$ 38.33	$ 12.59
Total	100	9069.1	-	-	244,199.1	-	70,817.7	4,604.9	681.5	-	-	$ 347,595.16	$769,666.66

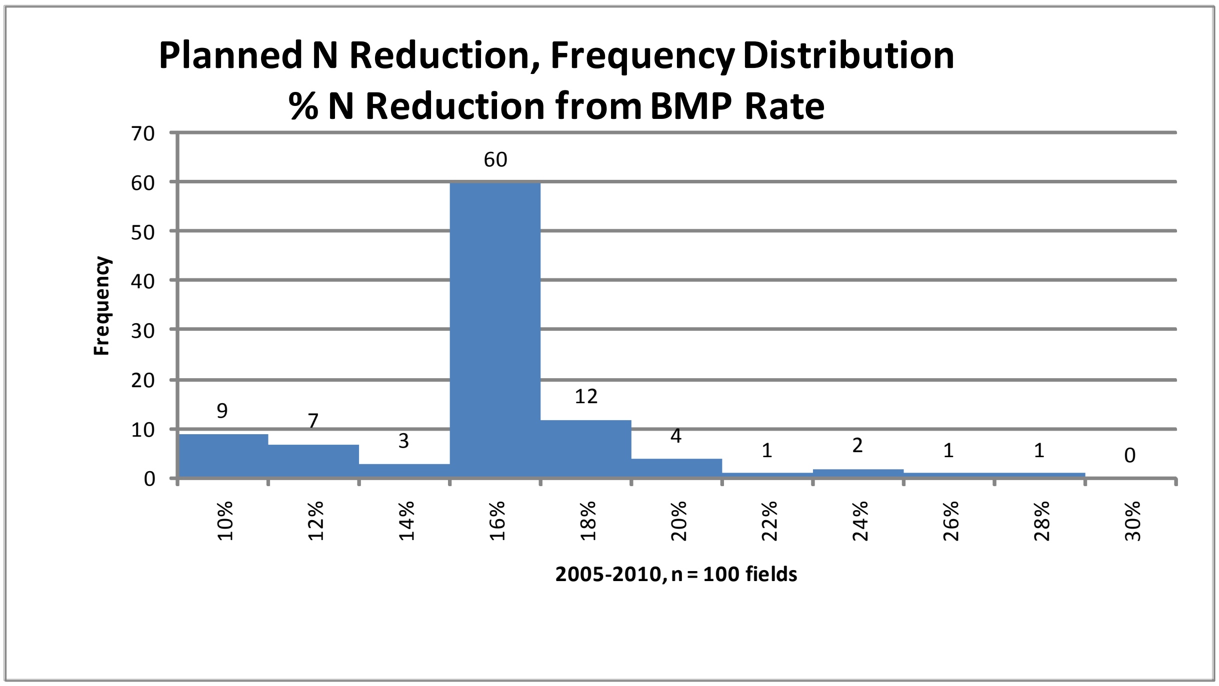
We calculated an average $12.59 cost per lb. of N-loss reduced by multiplying our total N-use reductions by an estimated average efficiency of 29%, i.e., each lb. of N not applied was estimated to result in 0.29 lbs. entering surface water (reduction in loss/reduction in amount applied). We chose 29% as a conservative estimate based on a review of the literature. Published estimates vary widely depending on soil type, slope, amount of excess fertilizer applied, tillage system and other factors. Efficiencies calculated for N management have ranged from 15% to 58%[30], including estimates that fertilizer applied

[30] Hall, D.W. and D.W. Risser. 1993. Effects of Nutrient Management on Nitrogen Fate and Transport in Lancaster County. *Water Resources Bulletin* 29: 55-76.
Hamlett, J. M., and D. J. Epp. Water Quality Impacts of Conservation and Nutrient Management Practices in Pennsylvania. *J. Soil and Water Conservation* 49(1994): 59-66.
McCarthy, J. and M. Kieser. 2011. *Developing a Systematic Approach to Generating Agricultural Nitrogen Credits from Planned Nitrogen Reductions in Pennsylvania and Evaluating Economic Feasibility*. Draft technical memo. 74 pp. (See Appendix A).

in excess of agronomic rates increase losses by a factor of three compared to applications at or below agronomic rates.[31]

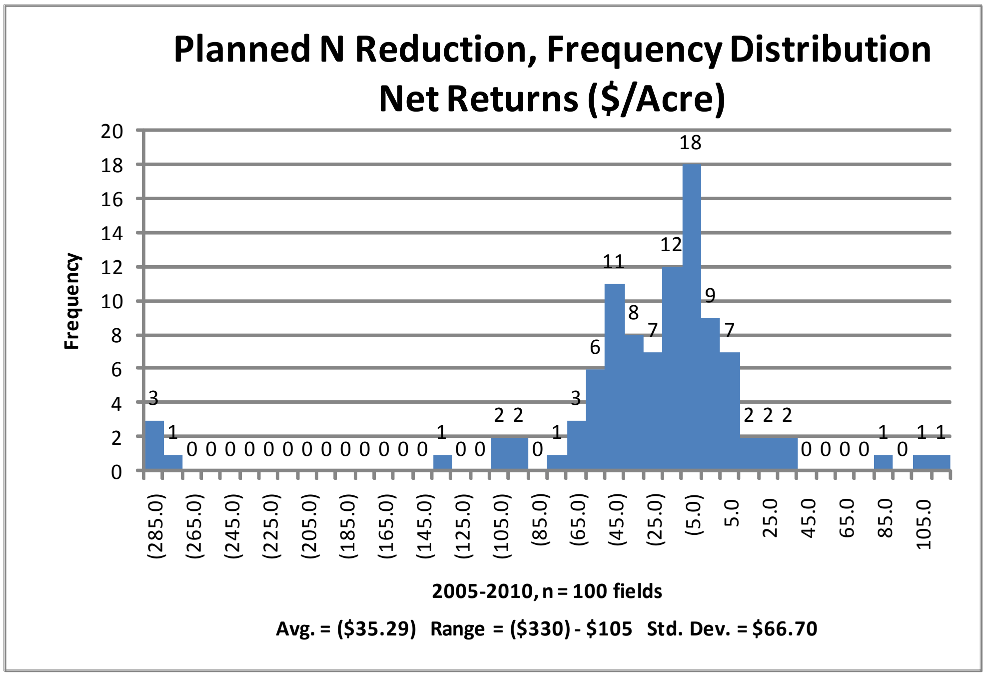
We then divided our total N-loss estimate by the cost of the program including crop advisor payments of $1500 per farmer (for farmer recruitment, reduction calculation, check strip layout and harvest supervision), farmer payouts per acre, a $30 per acre additional cost-share to farmers for time and equipment, plus estimated administrative costs of 30% of payouts and 5% contribution to reserves. Crop advisor and farmer payments varied somewhat from these numbers, e.g., in 2010, we reduced farmer payments to $15 per acre and crop consultant compensation was reduced to $1200 per farmer. Implications of these and other cost savings are discussed in Chapter 5.

Figure 2. Frequency of N reductions from BMP rates by percent for Planned N Reduction (PNR).



VanDyke, L.S. 1997. *Nutrient Management Planning on Virginia Livestock Farms: Impacts and Opportunities for Improvement.* M.S. thesis.192 pp. http://scholar.lib.vt.edu/theses/public/etd-39581323973910/etd.pdf
[31] Parsons, R. L., J.W. Pease and D.J. Bosch. *Simulating nitrogen losses from agricultural land: Implications for water quality and protection policy*. Water Resources Bulletin 31(6):1079-1087.

Figure 3. Frequency distribution of per acre net returns for 100 fields enrolled in PNR through 2010.



Split applications improved results. Producers who applied commercial N in more than one application (e.g., at or prior to planting, and a second application in late spring) experienced greater yields (and net returns) than for producers who made a single application (Table 3), although these differences were not statistically significant. Total application rates per acre were equivalent between the two groups; the only difference was the number of applications. Split applications, including minimum applications at or before planting, combined with late-spring applications[32] have long been recommended to improve N use efficiency. This strategy generally results in lower N losses because later applications are typically exposed to runoff, leaching and nitrification potential for a shorter duration, and are applied closer to crop need and use.

Corn for grain performed better than corn for silage. Producers growing corn for silage experienced lower yields and net returns than producers growing corn for grain (Table 3). These results, although not statistically significant, suggest nitrogen insufficiency may have a greater impact on corn biomass than corn grain. Similarly, drought stress has also been observed to impact silage yields more than grain yields[33]. Corn plants may divert resources to grain in the event of nutrient or drought stress. No attempt was made to assess grain or silage quality in conjunction with this project. Penn State

[32] Beegle, D., R. Fox, G. Roth and W. Piekielek. 1999. *Pre-sidedress Soil Nitrate Test for Corn.* Agronomy Facts 17. The Pennsylvania State University. 2 pp. http://cropsoil.psu.edu/extension/facts/agfact17.pdf

[33] Lauer, J. 2006. *The relationship between corn grain yield and forage yield: Effect of moisture, hybrid and environment.* Agronomy Dept., University of Wisconsin. 1 pp. http://corn.agronomy.wisc.edu/AA/pdfs/A045.pdf

recommendations call for 20 lbs. more N per acre for corn for silage vs. grain,[34] thus one might expect proportionately higher yield and net returns losses for silage.

Table 3. Difference in yield loss for grain and silage production when inorganic N was applied all at once or split over two applications.

	Yield loss (check strip yield minus BMP strip yield)	
	Grain	**Silage**
	(bu./acre)	(ton/acre)
Inorganic N applied all at once (n = 34 grain, 22 silage)	-13.0	-1.9
Inorganic N split application (n = 32 grain, 4 silage)	-11.9	-0.6

Manured acres. Seventy-one participants applied manure to provide a portion of N needs vs. 26 who applied only commercial fertilizer. Overall, participants applying manure experienced improved net returns of -$29.53/acre compared to growers not using manure -$38.64/acre, although this difference was not significant. Growers applying less than 50 lbs. manure experienced negative net returns of -20.46/acre (n=27), 50-100 lbs. resulted in a net of -$18.79 (n=28) and >100 lbs. resulted in a net of -$63.63 (n=16). These trends are consistent with the benefits of manure application including improved organic matter and soil structure, and slower release of N compared to commercial fertilizers, and also with elevated risk with increasing reliance on manure for a greater portion of the N need due to uncertainty inherent in calculating N value of manure.[35]

In 2009, 6402 “nutrient credits” were generated from several fields enrolled in Pennsylvania. These credits represent a portion of the nitrogen losses to surface water in the Chesapeake Bay Watershed and were calculated using a template created by Kieser & Associates and a calculator developed by the Pennsylvania Department of Environmental Protection and modified slightly for use in this project. Due to the lack of an active market at that time, these credits were “retired”, donated to Lancaster County and Pennsylvania DEP.

NUTRIENT BMP CHALLENGE

When participating farmers followed LGU-recommended BMPs for N management rather than their traditional practice, they reduced N use by an average of 37.4 lbs. per acre on 99 fields, for a total of 180,398 lbs. N-use savings (Table 4). A total of 4819 acres, or an average of 48.7 acres per field, was enrolled between 2000 and 2010. Participating producers were located in eight states: IA, IL, IN, MN, NE, OH and WI.

[34] Beegle, D.B. and P.T. Durst. 2011. *Nitrogen Fertilization of Corn.* Agronomy Facts 12. http://cropsoil.psu.edu/extension/facts/agronomy-facts-12
[35] Beegle, D.B., K.A. Kelling and M.A. Schmitt. 2008. Nitrogen from animal manures. In *Nitrogen in Agricultural Systems*. J.S. Schepers and W. Raun, eds. Amer. Soc. Agronomy. Pp. 823-867.

Using an estimate of 29% efficiency, these use reductions translate to loss reductions of almost 54,000 lbs. at an overall cost of $1.91 per lb. including costs of technical assistance (estimated average of $3.25 per acre), payments to farmers who experienced negative net returns ($12.93 per acre on average) and administrative and operating costs (30% of farmer guarantee payments plus a 5% contribution to reserves). Unlike PNR, participating farmers did not receive any additional cost-share payment for time or other costs.

N-fertilizer reductions also contributed to reduced emissions of N_2O, a potent greenhouse gas, by nearly 3450 lbs. Production of N fertilizer results in CO_2 emissions; by avoiding these applications, CO_2 emissions were reduced by 510 tons.

Nutrient management plans included a variety of basic BMPs, including crediting N from previous legume crops and any manure applications, typical of most nutrient management plans. Some producers also split applications to increase the amount of N applied closer to crop need or soil testing for nitrate N after crop emergence ("late spring" or "pre-sidedress" nitrate test). Approximately 10% of fields received manure. Another 10% credited legume applications. The remaining 80% relied on commercial fertilizer alone for N needs. Very few, if any, nutrient management plans were based on new N recommendation systems such as the Iowa N-rate calculator, which estimates an optimum range of N rates based on N fertilizer cost and expected corn selling price, and which have not yet been widely adopted.

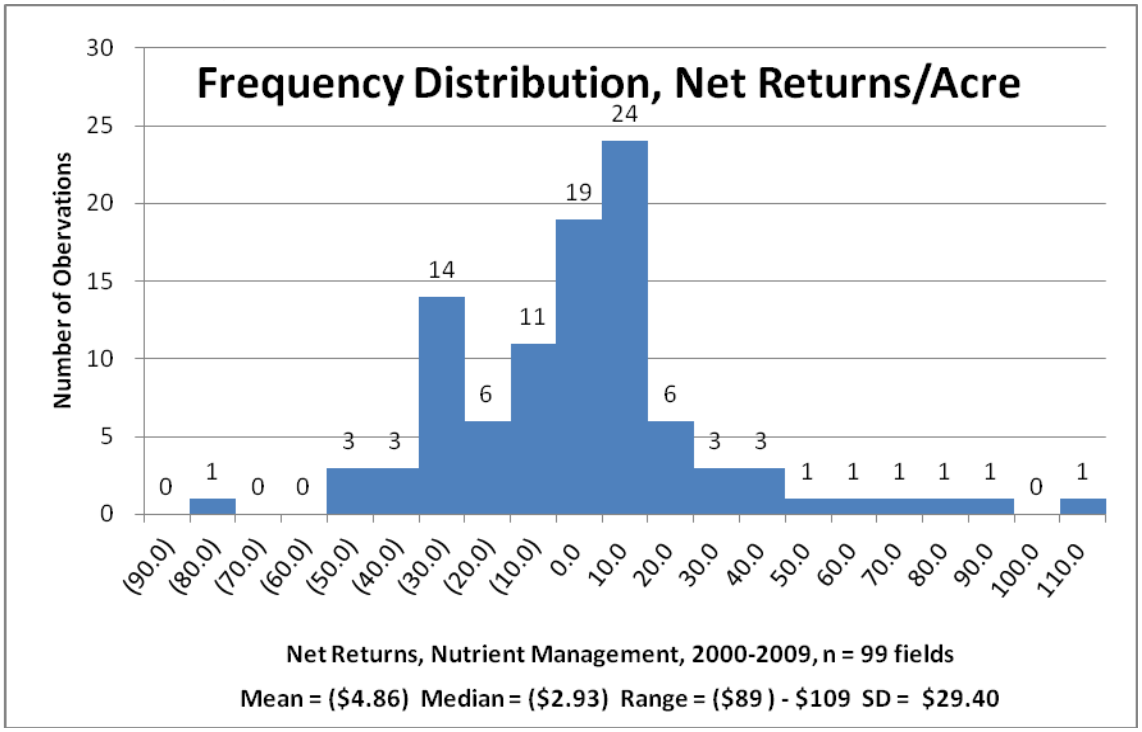
Participants achieved an average yield of 160.3 bu. on the BMP portion of the field vs. 167.0 bu. on the check strip. Farmer net economic returns averaged over the 99 fields were -$4.86 per acre, reflecting an average fertilizer savings of approximately $15 against an average yield value reduction of about $20. Given the uncertainty associated with nitrogen-need prediction, and the limitations yield-based recommendation systems, it is striking how well LGU-recommendations performed for our participants at an average loss of less than $5 per acre.

Table 4. Nutrient BMP CHALLENGE participation by year; N and corn prices; N, N loss, N_20, CO_2 reductions, average net returns, farmer payments and cost of N-loss reduction, 2000 through 2010.

Year	No. fields	Total acres	Avg. price N ($/lb.)	Avg. price corn ($/bu.)	Total reduction in N applied (lbs.)	Average reduction in N applied per field (lbs./acre)	Estimated total N loss reduction at 29% efficiency (lbs.)	Total N_2O reduction (lbs.)	Total CO_2 reduction (tons)	Average yield difference, BMP strip vs. check strip (bu)	Average net economic returns per field ($/acre)	Average payout to farmer ($/acre)	Avg. cost N loss reduction ($/lb.)
2000-05	31	1370.9	$ 0.23	$ 2.35	52,909.5	39.3	15,343.8	997.7	147.7	-5.2	$ (2.62)	$ 6.02	$ 1.02
2006	32	1406.0	$ 0.33	$ 2.20	54,841.0	43.2	15,903.9	1034.1	153.1	-6.4	$ 0.79	$ 11.89	$ 1.71
2007	19	805.1	$ 0.41	$ 3.50	37,962.3	46.9	11,009.1	715.9	105.9	-8.9	$ (10.64)	$ 16.29	$ 1.85
2008	14	935.9	$ 0.43	$ 4.75	26,314.5	36.0	7631.2	496.2	73.4	-10.6	$ (25.64)	$ 22.76	$ 4.17
2009	3	301.0	$ 0.74	$ 4.00	8,370.6	28.7	2427.5	157.8	23.4	8.5	$ 45.37	$ 4.06	$ 1.08
Avg./yr.	**20**	**963.8**	**$ 0.43**	**$ 3.36**	**36,079.6**	**38.8**	**10,463.1**	**680.4**	**100.7**	**-4.5**	**$ 1.45**	**$ 12.20**	**$ 1.96**
Avg./ac.	**-**	**-**	**$ 0.36**	**$ 3.07**	**-**	**37.4**	**10.9**	**0.7**	**0.1**	**-6.7**	**$ (4.86)**	**$ 12.98**	**$ 1.91**
Total	**99**	**4818.9**	-	-	**180,397.9**	-	**52,315.4**	**3401.8**	**503.5**	-	-	**$62,527.45**	**$ 100,073.61**

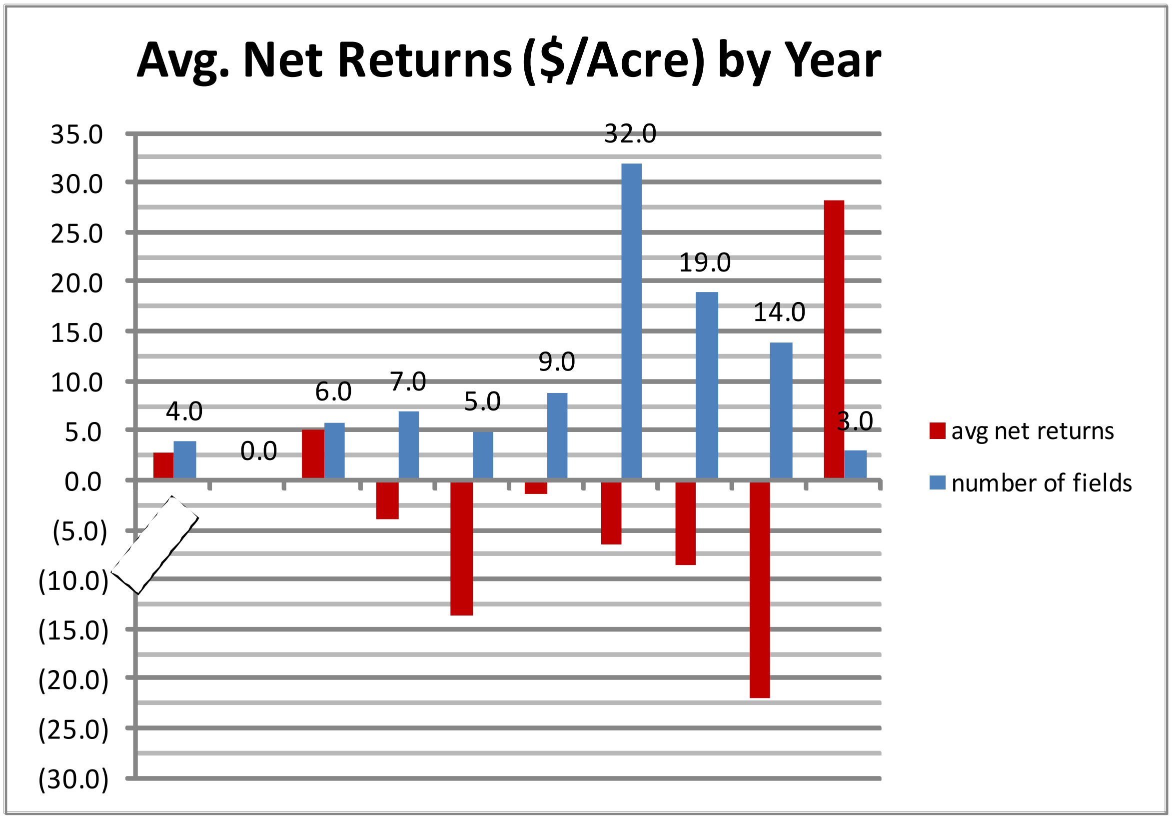
Net returns ranged from a low of -$90 per acre to a high of $110 per acre (Figure 4). . Farmers were compensated for negative net returns. Fifty-seven farmers received compensation averaging $12.93 per acre or $1008 per field, for a total of $62,527 in compensation. Forty-three fields had net returns within $10 of break even, with 19 of those fields at break even or less. A total of 42 fields experienced positive net returns. Thirty-eight fields experienced net losses greater than $10 per acre.

Figure 4. Frequency distribution of per acre net returns for 99 fields enrolled in the Nutrient BMP CHALLENGE through 2010.



Net returns varied considerably by year (Figure 5), with a high of $28 average net return in 2009 with four participating fields and a low of $22 average net return in 2008 with 14 fields enrolled.

Figure 5. Yearly average net returns in dollars per acre, and number of fields enrolled each year.



Negative net returns may have resulted from a number of conditions. These include:

1. Nearly all of the nutrient management plans for participating fields used a static N rate, e.g., 1.2 lbs. of N per bu. expected yield. This BMP does not take into account the increasing economic return for N applications as corn prices increase. N-rate recommendations from several Corn Belt LGUs now include a maximum-return-to-N approach, incorporating both corn price and N cost. (For example, see http://extension.agron.iastate.edu/soilfertility/nrate.aspx.) Most plans, while representative of typical plans used by most corn producers, also did not include all possible opportunities to improve N-use efficiency such as split applications, controlled release formulations, etc.

2. The static rate of N per bu. expected yield has not changed in many years, and may not be adequate for newer varieties that are higher yielding, or that may require more N (e.g., varieties with plant-incorporated pesticides for corn rootworm).

3. University-developed BMPs are not designed to maximize yield but to optimize net income over time. Corn yields have been generally higher than average in recent years, with average yield per acre in the US higher than the 2000-2009 average in every year from 2004 to 2009. We are overdue for a year when moisture, heat or sunlight conditions limit production and reduce returns to N.

4. Higher-than-average rainfall amounts and intensity between the time of N application and crop need may result in higher-than-expected N losses and reduced yields. We experienced unusually heavy rainfall in a number of cases that may have contributed to the negative net return observed here.

The large number of variables encountered during the course of this project, including geography, weather conditions, varieties, BMPs, tillage practices, etc., precludes a definitive determination of the cause of the negative net return observed here.

We calculated an average $1.91 cost per lb. of N loss reduced by multiplying N-use reductions by an estimated efficiency of 29%. We then divided our total N-loss estimate by the cost of the program including crop advisor payments of $3.25 per acre for check strip layout and harvest supervision, farmer payouts per acre, plus estimated administrative costs of 30% of payouts, plus a contribution to reserves of 5%.

Assuming average total corn production of 190 acres per farm, reductions achieved here translate into annual reductions of 469,699 lbs. of N use and 136,213 lbs. of N-loss reduction on participating farms post-BMP CHALLENGE. Recent Conservation Effects Assessment Program reports suggest that 15% to 20% of US cropland lacks basic nutrient management practices. If N-loss reductions achieved here were made on 15% to 20% of the 88 million corn acres grown in 2010, we would have achieved N loss reductions of 143 million to 191 million lbs. at a total cost of $273 million to $365 million. These initial costs could be reduced by 75% by enrolling just 25% of acres managed by farmers not currently using basic nutrient BMPs. Assuming 59% of these producers continue to follow the BMP and expand the practice to all of their corn acres, we could achieve these N-loss reductions each year for the nominal cost of updating nutrient management plans for each field.

REDUCED TILLAGE BMP CHALLENGE

Forty-two fields for a total of 2313 acres were enrolled in the BMP CHALLENGE for conservation tillage from 2006 through 2009 (Table 5). A variety of tillage systems were used, primarily no till but also a limited number of strip and ridge till fields.

We used flat rate formulae to estimate sediment reduction (1.5 tons per acre), P loss reduction (2 lbs. per acre) and CO_2 reduction (0.5 lbs. per acre). Tillage cost reductions were calculated primarily from the Purdue WinMAX program, although some participants used estimates provided by their crop consultants from local LGU recommendations.

Program costs included farmer payouts, $6 per acre crop consultant fee for check strip set up, harvest assessment and technical assistance for tillage equipment set up and two visits during the season to evaluate progress and recommend adjustments if needed, plus 30% administration and 5% contribution to reserves.

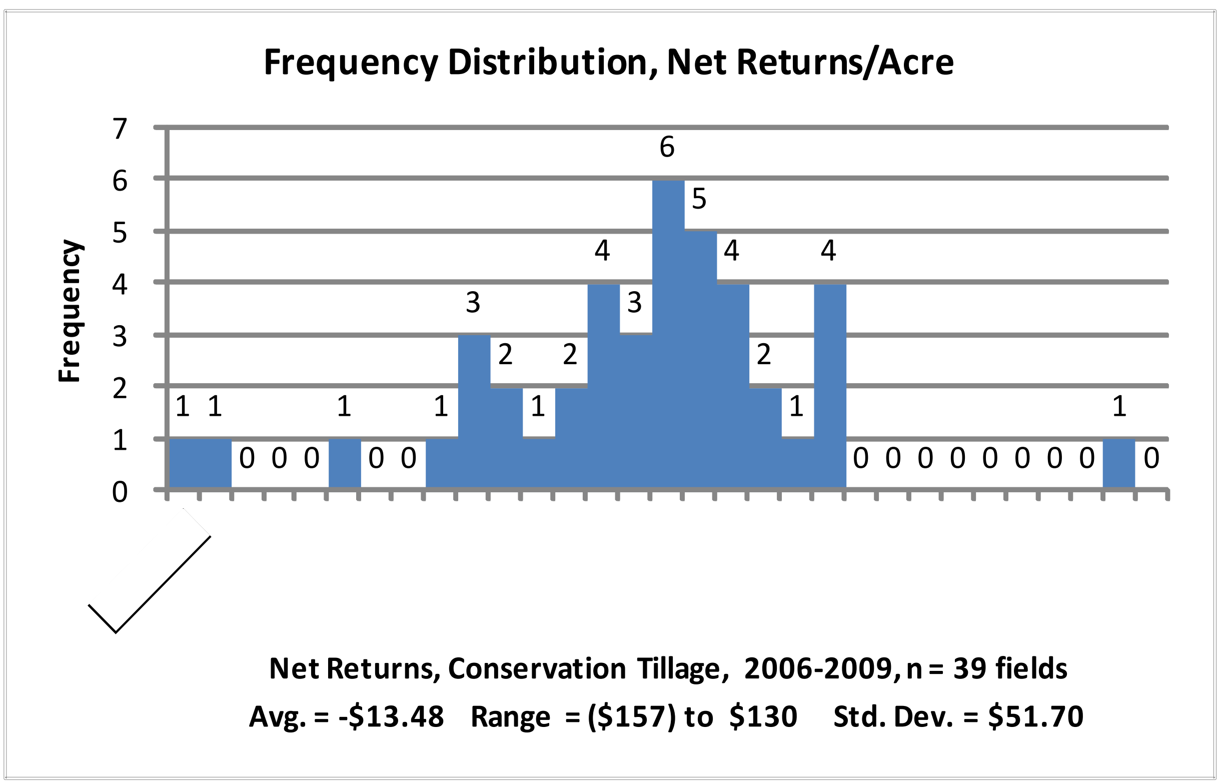
On average, participants experienced a 9.4 bu. loss and net returns of -$13.48 per acre after factoring in an average tillage cost savings of $14.25 per acre. Net returns ranged from a high of $130 to a low of -

$157. Nineteen of 42 producers experienced negative net returns (Figure 6). Nine producers were within $10 of breakeven.

Table 5. Reduced Tillage BMP CHALLENGE participation by year, sediment, phosphorus (P), CO_2 reduction, tillage cost reduction, net economic returns and program costs, 2006-2010.

Year	No. fields	Total acres	Avg. price corn ($/bu.)	Total sediment loss reduction (tons)	Total P loss reduction (lbs.)	Total CO_2 Reduction (lbs.)	Average tillage cost savings per field ($/acre)	Average yield difference, BMP strip vs. check strip (bu.)	Average net economic returns per field ($/acre)	Average payout to famer ($/acre)	Average program cost ($/acre)	Average sediment loss reduction per field (tons/acre)	Average P loss reduction per field (lbs.)	Average CO_2 reduction per field (lbs./acre)
2006	13	614.1	2.20	921.2	1,228.2	307.1	$ 8.97	(19.7)	$ (34.40)	$ 30.37	$ 47.00	70.9	94.5	23.6
2007	13	525.4	3.50	788.0	1,050.7	262.7	$ 10.84	(4.0)	$ (2.10)	$ 30.14	$ 46.69	60.6	80.8	20.2
2008	8	561.1	4.75	841.6	1,122.1	280.5	$ 16.71	(4.7)	$ (5.87)	$ 21.08	$ 34.46	105.2	140.3	35.1
2009	5	351.3	4.00	527.0	702.6	175.7	$ 5.00	(6.8)	$ (21.70)	$ 24.24	$ 38.73	105.4	140.5	35.1
2010	3	261.0	3.90	391.5	522.0	130.5	$ 40.70	(4.6)	$ 21.24	$ 11.74	$ 21.85	130.5	174.0	43.5
Avg./yr.	**8**	**462.6**	**3.67**	**693.8**	**925.1**	**231.3**	**$ 16.44**	(7.9)	$ (8.57)	$ 23.52	$ 37.75	3,000.0	111.7	31.5
Avg./acre	**-**	**-**	**-**	**1.5**	**2.0**	**0.5**	**$ 14.25**	**(9.4)**	**$ (13.48)**	**$ 25.03**	**$ 33.80**	**1.5**	**2.0**	**0.5**
Total	**42**	**2,312.8**	**-**	**3,469.2**	**4,625.6**	**1,156.4**	**$32,957.62**	**-**	**-**	**$57,893.88**	**$78,162.74**	-	-	-

Figure 6. Frequency distribution of net returns per acre for reduced tillage, 2006-2010.



PRODUCER SATISFACTION

In early 2011, American Farmland Trust and Agflex conducted two surveys including an end-of-year survey of 2010 participants and a survey of participants from 2004 through 2009. Responses were received from 19 of 31 2010 participants (61%) and 18 of 62 pre-2010 participants (29%). Both surveys contained ten identical questions allowing those responses to be combined for analysis.

Producers were overwhelmingly satisfied. Thirty-three of 37 respondents (89%) were satisfied that their income had been protected. All but one of the 37 respondents (97%) said that the method to determine the net returns and calculate guarantee payments was accurate and fair. Seventy percent of respondents cited economic benefits of the practice and educational value as "very important." Fifty-six percent cited "benefits to the environment" as very important.
Comments included:

- *I think this program is a fantastic approach to implement solutions to cleaning up the bay. It takes the worry out of changing management practices that directly effect yield/income.*
- *It is a win-win situation. I can try new practices with little risk.*

The income guarantee and technical assistance are important. Of 29 respondents who used nutrient management practices, 55% reported the net income guarantee influenced them "a great deal," suggesting that without it they may not have adopted the practice. An additional 34% said they were somewhat influenced and 10% indicated "very little." Among the 11 respondents who tried reduced tillage, 45% indicated the guarantee influenced them "a great deal." Three respondents each saying there was some or very little influence.

Seventeen of 18 respondents (94%) rated both "fear of yield loss" and "cost versus profit" considerations were "very important." Fourteen (78%) rated "availability of information" as "very important."

Participants improve practices on a majority of their acreage as a result of participation. Fifteen of 17 (87%) responding past participants for nutrient management indicated they are using the practice or a modified version. Eleven indicated how much of their cropland they have adopted the practice on, with an average 60% of acreage reported.

Of the end-of-year respondents, 15 of 19 respondents reported having adopted the practice or a modified version. For the eleven who indicated how much of their land they have adopted it on, the average is 54% of acreage.

Of all respondents indicating they did not continue the practice, 71% indicated the reason was fear of income loss.

Comments included:

- *[My]) Soybeans [and] corn do not receive as much purchased fertilizer now due to better knowledge of yield at a lower nitrogen rate.*
- *Adopted some nitrogen rates depending on soil, manure and rotation.*
- *Reduced tillage 100% following soybeans.*
- *I'm still undecided on how I'm going to proceed in the future.*

Participants are willing to contribute when they have a net income gain. The BMP CHALLENGE program asks farmers who experience a net returns gain to contribute one third of their gain, up to a maximum of $6 per acre, to the program to support participation by additional producers. Total contribution requests have averaged $2,300 per year since 2006. Seventy-three percent indicated they would contribute; 88% said the contribution request would not keep them from participating. Comments on farmer contributions included:

- *[I would consider contributing] to keep the program going for someone else. I learned from it.*
- *Rebating part of my gain would be a small price to pay for knowledge gained which could be used across more acres later. A participation fee is only a percentage of added gain so you really haven't lost anything. This information can be used on more acres in the following years to increase net income.*

BMP CHALLENGE availability would influence adoption of additional practices. Our end-of-year survey asked participants to indicate whether or not they have adopted any of eight BMPs and if not, whether they would adopt "if the BMP CHALLENGE were available." Of respondents not yet adopting the practice, 50% overall indicated that they would adopt if the BMP CHALLENGE was available, with greater willingness to adopt some practices over others (Table 6). Although ours was a small sample, results suggest further investigation may reveal specific high water-quality-gain practices that may benefit disproportionately from the BMP CHALLENGE.

Table 6. Affect of availability of BMP CHALLENGE on adoption of specific practices.

13) Are there other agronomic BMPs that you have not yet adopted that you would consider adopting IF the BMP CHALLENGE was available to you? If so, what practices are they?	Have Adopted	Would Adopt	Would Not Adopt	% Would Adopt with Guarantee
No till – conservation till	11	1	1	50.0%
Implement a nutrient management plan	11	1	1	50.0%
Use pre-sidedress nitrate test	6	5	2	71.4%
Use corn stalk nitrate test	8	3	2	60.0%
Use N inhibitors or enhanced N products such as slow release	7	5	2	71.4%
Manure incorporation, e.g., vertical tillage, field cultivator	2	5	6	45.5%
Manure injection	0	5	8	38.5%
Variable rate/precision nutrient application	0	10	3	76.9%
Total/average	**43%**	**58%**	**42%**	58.0%

Participants want the BMP CHALLENGE to be broadly available. Thirteen of 17 respondents (76%) indicated the "yield guarantees should always be offered to farmers considering a new best management practice." Comments included:

- *Guarantee will always allow for quicker adoption of a practice.*
- *Both years I did this, the extra nitrogen (check strip) increased the yield for more than the cost of the N so I was reimbursed.*
- *You will get more participants.*
- *This will give producers more confidence to try new practices.*
- *If practice is not costing us much, why pay, but it will encourage participation.*
- *There are a lot of ways to attract participants. A flat fee may also work for some programs.*

Corn price variability can influence satisfaction. One comment echoed sentiments expressed by a number of farmers in 2009 when, during the growing season, corn prices rose beyond the USDA Risk Management Agency base price that was determined in January and which is used by the BMP CHALLENGE and PNR programs. This meant that portion of actual losses was not covered, although had prices changed in the other direction, farmers would have received more than actual losses.

Moral and morale hazard are not likely to be an important issue. During development of the Federal Crop Insurance Corporation pilot in 2001-2003, concerns were expressed about the moral hazard or the potential for farmers and/or consultants to deliberately manipulate results to cause a net economic loss and thus a payment. For example, PNR participants could apply more N to the check strip than Penn State recommendations, or Nutrient BMP CHALLENGE participants could apply more to the check strip than he or she traditionally applies, to increase check-strip yields. Morale hazard was also a concern, i.e., the farmer or consultant could fail to act in such a way as to make a payment more likely. For instance, a farmer might apply an insecticide to the check strip only, and leave the balance of the field untreated.

To date, we have not experienced a single incident of suspected or confirmed moral or morale hazard. The mechanics we have developed work against both hazards, including requiring a certified crop consultant to work on site with the farmer. Applying additional N to the check strip would likely result in at most a $5/acre increase in net returns payment on average. The crop consultant is required to inspect the field at harvest and report any differences between the check and comparison strips in insect, disease or weed pressure, or plant population. Complicity by the crop consultant would put their certification at risk. Fertilizer purchase and nutrient application records are subject to audit as a condition of participation.

AGFLEX FINANCIAL PERFORMANCE

Agflex was incorporated in Iowa as a for-profit corporation in 2000 after the collaborators were unable to find an existing entity willing to bear the responsibility and risk associated with payments to farmers of uncertain amounts. Lack of proof of market and insufficient data available to document frequency and amounts of payouts were a barrier for traditional insurers and reinsurers, including crop insurance companies. A federally approved nutrient BMP crop insurance endorsement introduced in 2003 experienced very low participation by insurers and was withdrawn from the market.

Agflex was formed and reserves created by borrowing funds from the Iowa Department of Economic Development and American Farmland Trust. Agflex provides commercial service agreements to farmers, not insurance policies. Agflex provides consulting and special expertise to participating farmers and provides a contractual performance guarantee for that the advice and service. Agflex's commercial service agreement does not provide indemnification for fire, wind, hail, flood, drought or other perils typically covered by insurance. The check strip approach effectively isolates differences in yield to the practice implemented with the advice of the crop consultant provided by Agflex.

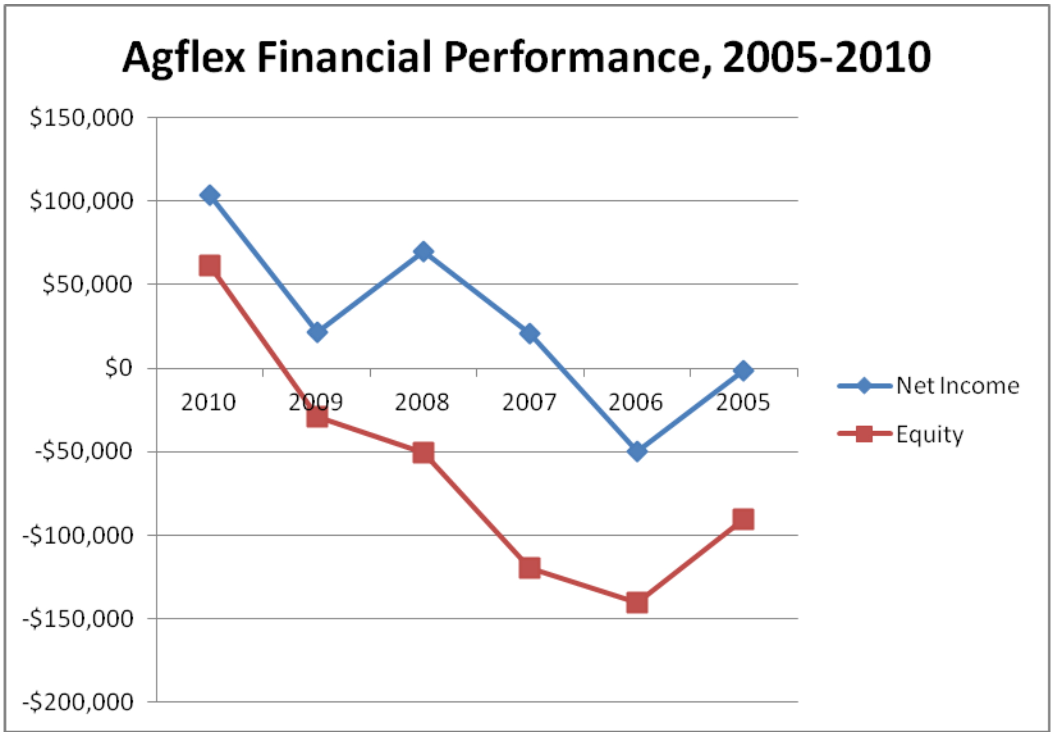
Beginning with the 2007 growing season, Agflex developed a per-acre-fee calculation based on the historical payouts for each of the three programs (PNR, nutrient BMP and reduced tillage). The fee is based on historical payouts, adjusted for the current year corn price, plus administrative costs of 30% and contribution to reserves of 5%.

The administrative portion of the fee pays for staff time to prepare/update forms, correspond with project partners including crop consultants and producers, respond to inquiries, pursue and receive completed forms from participants, enter data, calculate net returns, report results back to crop consultants and producers, and administer farmer and crop consultant payments, etc. These costs are the variable costs associated with having acres on the ground.

The advantage of developing a flat fee regardless of actual payouts is that producers are guaranteed full compensation for negative net returns regardless of availability of grant funds. Agflex commits in writing to provide full payment to producers and maintains adequate reserves to make full payment in the event of a worst-case scenario. Each year, Agflex calculates worst case scenarios and limits acres enrolled to stay within its capacity to make payments.

Through 2010, payouts to farmers have ranged from a low of 14% of fees (2009 nutrient management, 319 acres enrolled) to a high of 83% (planned N reduction, 2459 acres enrolled). Overall, on average, Agflex has paid out to farmers 65% of the guarantees it charges to funders, maintaining its planned 35% gross margin (fees minus payouts) Agflex estimates it requires to remain sustainable, i.e., maintain sufficient reserves to make payments in worst case years, meet obligations to its initial creditors and continue to expand the program. Agflex has been profitable since 2007 (Figure 7). All after-tax earnings to date have been retained by the corporation to meet reserve requirements.

Figure 7. Agflex financial performance, 2005-2010. Net income includes total income from grants, contracts and guarantee fees, minus expenses including personnel, travel, equipment, supplies and overhead. Equity reflects assets including cash in banks and receivables, minus payables including loan principal and outstanding interest. Gross margin is the percent of guarantee fees retained after net income guarantee payments to farmers.



Additional costs to Agflex for grant-funded projects include coordinating project conference calls, recruiting participants, preparing grant performance reports, data analysis, results summaries, etc., bookkeeping, grant financial reports, preparing and administering subcontracts, invoicing funders, processing/paying subcontractor invoices, payroll, etc. These additional costs also include personnel costs for administering the project overall, project planning and evaluation, supervising staff, working with subcontractors, development for new crops and practices including data analysis and projections, meetings, conference calls, emails, presentations at conferences, etc. These are costs associated with running the project and developing the BMP CHALLENGE program and are included in personnel and fringe budget lines in proposals to funders. Payments to crop consultants are included in the contractual line item.

Agflex provides a model for a new type of Technical Service Provider, identifying late-adopter farmers, providing both technical assistance and verified foregone income protection, and increasing adoption. At 35% ratio of expense to delivery of foregone income payments to farmers, Agflex is cost efficient compared to NRCS which we estimate runs a 40% ratio of expense to delivery of program funds to farmers. Agflex is cost efficient compared to crop insurance companies that from 1995 through 2010 received administrative and operating cost reimbursements from the federal government averaging 26.7% of indemnities plus retained 23.7% in underwriting gains.[36] In addition, Agflex targets payments to farmers with opportunities to improve practices, verifies implementation, documents outcomes including impacts on yields, net income and natural resources, and compensates only those farmers suffering net economic losses.

5. Feasibility for Contributions to Bay Water Quality

A wide variety of practices have been developed which help protect natural resources from impacts of agricultural production, including both long-term structural practices and seasonal practices. Many of these practices incur costs to producers and require additional resources to implement. Costs include investment in time, materials, opportunity costs and foregone income due to lost production. Costs may be offset by fertilizer or fuel input savings or improved yield or quality, but few practices are cost neutral or provide a net return to the farmer.

Our results indicate that reducing N application rates below LGU recommendations by 15% reduces net returns by an additional $35.29 per acre on average over the wide range of corn prices, N costs, N BMPs, weather conditions, soil types, yield potentials and varieties experienced in our pilots. Nutrient management practices employed by farmers in our pilots generated a much smaller negative net return of -$4.86 per acre on average.

These costs, plus additional costs for farmer recruitment, cost share (PNR only), development of a basic nutrient management plan, farmer recruitment, yield checks at harvest, administration and contribution to reserves, translate into average costs per lb. of N loading reduction of $12.59 and $1.91 per lb. of N respectively, at 29% efficiency. Updating these average costs to a corn-for-grain price of $6.01 per bu. results in average costs of $14.65 per lb. of N loss reduction for PNR and $4.66 per lb. for the Nutrient BMP CHALLENGE (Table 7).

[36] Environmental Working Group. 2011. *Crop Insurance in the United States.* 2011 Farm Subsidy Database. http://farm.ewg.org/cropinsurance.php

Comparison Against Historical Cost Projections and Other Practices

Planned N Reduction. The concept of applying nutrients below rates recommended by university experts first appeared in print in 2001 as one of 95 policy recommendations to USDA from the Agricultural Policy Project of the Henry A. Wallace Center[37]. The recommendation, referred to as "enhanced nutrient management" followed a five-year visioning process involving more than 350 individuals and addressing key environmental, economic, social and other issues impacting food and agriculture policy. This recommendation was among several addressing nutrient management planning, including developing farm and watershed-based plans, and creating nutrient standards and a nutrient reduction trading program. The report did not quantify cost or benefit estimates.

The concept proposed included farmer incentives and/or yield loss insurance, suggested N application rates at 75-89% of recommended and assumed "current recommendations have a sufficient safety margin to limit exposure of farmers to yield risk". This assumption we now know to be unfounded for the range of soil types, growing conditions, rainfall amounts, etc. we experienced. Only sixteen of 100 PNR fields and 43 of 99 Nutrient BMP CHALLENGE fields experienced positive net returns.

In 2004 with corn at $2 per bu., enhanced nutrient management was projected to cost $4.41 per lb. (Table 7), which increases to $8.41 at $6/bu. corn using the 1:1 relationship between corn price and N-loss-reduction cost described in Figure 8. A subsequent 2007 publication estimated much higher costs of nearly $50 per lb. of N-loss-reduction.

Actual costs experienced here, adjusted to $6.01 corn, were $14.65/lb. of N-loss reduction overall and $16.15 for corn-for-grain only. These costs translate to an annual investment of $50 million to achieve 20% of Pennsylvania's commitment to N-load reductions. These costs are approximately double estimated costs for reductions generated from cover crops.

Our data do not suggest any conditions likely to consistently result in positive net returns from PNR, although we did not focus efforts on conditions hypothesized as potentials such as sandy soils with low moisture-holding capacity that may experience moisture limitations more frequently than N insufficiency. These soil types are extremely uncommon in Pennsylvania, but more common in other states such as Maryland.

In addition, over the course of the project, a number of individuals, including key influencers of policy, expressed objections about the concept of compensating farmers for producing less corn. Concerns have included:

[37] Clancy, K., E. Higgins and L. Obeholtzer. 2001. *Making Changes: Turning Local Visions into National Solutions: Agriculture and Rural Development Policy Recommendations from the Agriculture Policy Project.* Henry A. Wallace Center for Agricultural & Environmental Policy at Winrock International, Arlington, VA. 86 pp. http://www.winrock.org/agriculture/files/makingchanges.pdf

- Increasing nitrogen use efficiency through right timing, product, placement and rate may achieve comparable reductions in nitrogen losses without reducing yields.
- Long-term reductions in nutrients below agronomic optimum will reduce soil fertility.
- Reducing corn yields will increase the region's corn production deficit and lead to more acres planted in the region, offsetting the total N reduction
- Producing lower yields is too strong a cultural taboo to agricultural producers and participation will be insufficient regardless of guarantee payments.

Nutrient BMP CHALLENGE. In contrast to PNR, Nutrient BMP CHALLENGE results to date indicate the practice is 37% less expensive than cover cropping. At $4.66 per lb. of N-loss reduction, an annual investment of $21 million at current corn prices would generate 26% of Pennsylvania's commitment. This estimate assumes a 37.4 lb. per acre reduction in N application rates to meet LGU recommendations, consistent with our results to date in a dozen states. If long-term adoption rates are consistent with those experienced to date, an up-front investment of $6 million could deliver nearly approximately 15% of Pennsylvania's commitment to N-load reductions on a sustained basis at no additional cost.

Other Practices

In addition to cover crops estimated at $7.34 per lb. of N-load reduction, other potential practices and recent cost estimates include manure relocation at $2.32 per lb., riparian forest buffers at $4.25 per lb., riparian grass buffers at $6.05 per lb., water control structures at $1.69 per lb. and wetland restoration at $6.80 per lb.[38] Riparian forest buffers have also been estimated at $1.57 to $6.79 per lb., and grass buffers at $1.57 to $6.79 per lb.[39]

[38] Dept. of Natural Resources and Environmental Control Division of Water Resources Watershed Assessment Section. 2008. *Regulations Governing the Pollution Control Strategy for the Indian River, Indian River Bay, Rehoboth Bay, and Little Assawoman Bay Watersheds*. State of Delaware. 26 pp. http://www.dnrec.delaware.gov/wr/Documents/IBPCS_Effective_111108.pdf

[39] Wieland, R., D. Parker, W. Gans and A. Martin 2009. *Costs and Cost Efficiencies for Some Nutrient Reduction Practices*. Main St. Economics and Dept. of Agric. And Resource Economics, University of Maryland. 65 pp. http://www.envtn.org/uploads/Final_BMP_Cost.pdf

Table 7. Cost comparison for N-loss reduction options including past estimates for applying N at below agronomic rates from two publications, which have not been adjusted to current corn prices. PNR cost calculations are based on our 2005-2010 results adjusted to current corn prices, and include a $15 per acre farmer cost-share, a $12 per acre crop consultant fee, and administrative and operating costs of 35% of the average corn-price-adjusted historical PNR farmer payout per acre (currently paid to Agflex). Nutrient BMP CHALLENGE (Nutrient BMPC) costs include the consultant fee and administrative costs, but farmers do not receive a cost-share payment. PNR and BMPC acreage targets represent those acres identified by Keiser and Associates as at greatest risk of N losses to the Bay (Appendix A).

	Cost ($/ac)	**Corn price basis ($/bu.)**	**Average N application reduction (lb./acre)**	**Average N load reduction (lb./acre)**	**Cost N reduction edge of field ($/lb.)**	**Cost N loss reduction to Bay ($/lb.)**	**Estimated efficiency**	**Target acres**	**Potential N-load reduction (lbs.)**	**% of goal**	**Total cost**
Pennsylvania WIP goal									**17,307,180**		
Enhanced nutrient management[1]	$40.00	$ 2.00	-	3.72	-	$ 4.41	-	6,375,000	23,700,000	137%	$104,517,00
Yield reserve[2]	$55.30	$ 2.58	11.4		$14.49	$ 49.98	29%	34,797	807,380	5%	$10,133,568
Traditional nutrient management[1]	$7.00	$ 2.00	-	4.19	-	$ 1.66	-	3,242,857	13,600,000	79%	$22,700,000
Cover crops[3]	$33.33	$ 4.10	-	4.5		$ 7.34		473,477	2,150,000	12%	$15,781,000
PNR, -15%	$ 120.50	$ 6.01	26.9	7.8	$4.48	$ 15.45	29%	416,797	3,251,433	19%	$50,224,039
PNR, -15%, grain only	$ 122.70	$ 6.01	26.2	7.6	$4.68	$ 16.15	29%	416,797	3,166,824	18%	$51,140,992
PNR, -15%, split N application	$ 111.50	$ 6.01	26.9	7.8	$4.14	$ 14.29	29%	416,797	3,251,433	19%	$46,472,866
Nutrient BMPC	$ 50.56	$ 6.01	37.4	10.8	$1.35	$ 4.66	29%	416,797	4,520,580	26%	$ 21,073,25
Nutrient BMPC (25% of critical acres)	$ 50.56	$ 6.01	37.4	10.8	$1.35	$ 4.66	29%	104,199	1,130,145	7%	$5,268,314

[1]*Cost-Effective Strategies for the Bay*, 2004. Total cost reported here is for N only, vs. N plus P cited by the authors.

[2]Metcalfe *et al.*, 2007. We estimated costs by adding the crop consultant fee ($12 per acre) to the incentive plus insurance option described by the authors.

[3]Kieser & Associates, 2011. Costs calculated by adding 25% to NRCS cost-share rate; N-loss reductions calculated using the PA DEP nutrient credit calculator.

Sensitivity of Performance Guarantee Costs to Corn Price and Other Factors

Corn prices are the major factor affecting program costs. For each dollar increase in corn price, PNR costs increase by approximately $16 per acre and $1 per lb. of N-loss reduction (Figure 8). Nutrient BMP

CHALLENGE costs increase by $6 per acre and $0.25 per lb. of N-loss reduction. Thus it follows that the greatest potential for reducing program costs is reducing yield reductions, i.e., by choosing practices that minimize negative impacts on yield.

Field size impacts costs per acre and costs per lb. N-loss reduction if consultants are paid a flat fee per field. Most consultant costs, e.g., time and travel, are independent of field size. The consultant makes the same number of trips to the farm, and sets up only one set of comparison strips, regardless of field size. If consultants are paid an average of $1200 per field, costs range from $20.58 per lb. of N-loss reduction for PNR and $7.12 for Nutrient BMP CHALLENGE for 25-acre fields, to $15.84 to $4.16 for 100-acre fields (Figure 9). Costs remain the same regardless of field size if consultants are paid a per acre rate, which has been done for the majority of BMP CHALLENGE fields to date. The per-acre rate has not been attractive to consultants in areas with high costs of living and/or smaller fields sizes including the Mid-Atlantic and California. Increasing the number of fields per farm has potential to reduce costs further given the fixed costs associated with travel and travel time to the farm. Given the geographic concentration of high-loss-potential acres (Appendix A, Figure 2-2), enrolling multiple fields per farm is a recommended strategy to minimize costs per lb. of N reduced.

Figure 8. Sensitivity of cost per lb. N-loss reduction to corn price, currently $6.01/bu

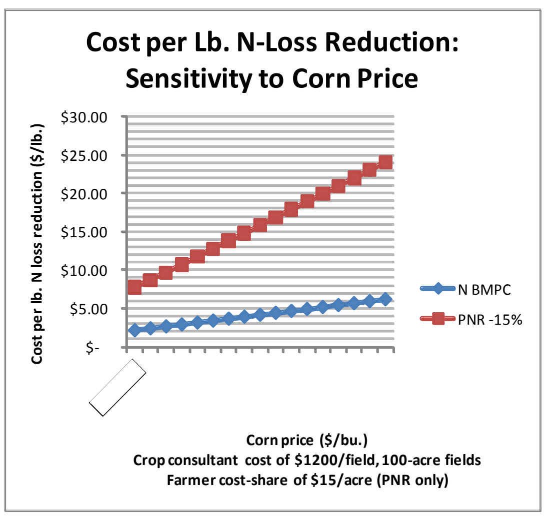
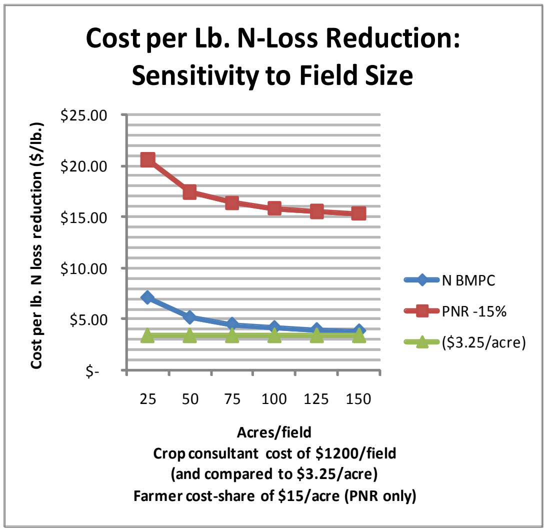


Figure 9. Sensitivity of cost per lb. N-loss reduction to field size, currently at an average of 48.4 acres/field for BMP CHALLENGE and 90.7 acres/field for PNR. Compares a flat rate of $1200 per field for both programs and to a $3.25/acre fee for BMP CHALLENGE.



Farmer cost share and consultant fees increase cost per lb. of N-loss reduction by $0.08 to $0.13 per dollar increase (Figures 10 and 11). Agflex fees increase costs by $0.02 to $0.09 per percentage increase (Figure 12).

Figure 10. Sensitivity of cost per lb. N-loss reduction at 29% efficiency to farmer cost-share rates, currently at $15 per acre for PNR only. BMP CHALLENGE programs do not currently provide a cost-share payment to farmers.

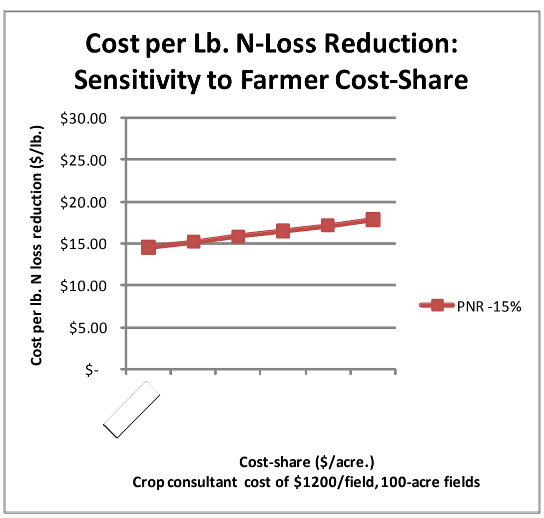


Figure 11. Sensitivity of cost per lb. N-loss reduction at 29% efficiency to crop consultant fees, currently at $650 to $1400 per farmer depending on practice and location.

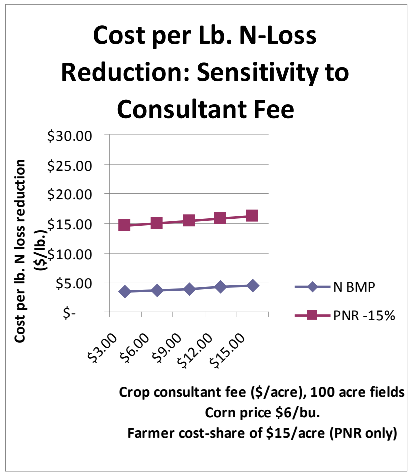
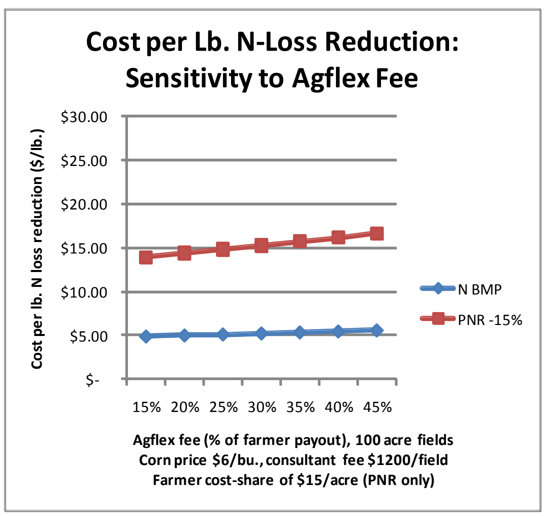


Figure 12. Sensitivity of cost per lb. N-loss reduction at 29% efficiency to Agflex fees, currently at 30% plus 5% contribution to reserves.



Additional Factors Impacting Feasibility

The region's corn deficit would increase. To maintain the deficit at current levels, replacement of corn not produced would entail approximately 11.9 bu. per acre for PNR and 6.7 for the Nutrient BMP CHALLENGE. Using 150.5 bu. per acre as average production at LGU-recommended N rates, an additional acre of corn would be needed for every 12.6 acres of PNR corn, and for every 22.5 acres of LGU-rate corn. Under the guarantee mechanics, participating farmers are currently compensated for the cost of replacing this corn. N losses from this additional production would "discount" loss reductions by an estimated 16 lbs. of N per acre of replacement corn if all it were produced in the watershed using LGU-recommended N rates.

N management does not create excess manure. Manure applications to corn in Pennsylvania are typically limited by phosphorus, i.e., applying the entire N requirement in manure would exceed phosphorus needs. Therefore we have not included costs for alternative deployment of manure.

Availability of crop consultants is unlikely to be a barrier. Given the average field size enrolled in Pennsylvania to date of 90 acres, approximately 4600 fields would need to be enrolled to cover 416,797 most-at-risk acres. If an average of 360 acres or four average-size fields were enrolled per farmer, 1150 farmers would participate, requiring an estimated 46 consultants at a rate of 20 farmers per consultant. Twenty is the approximate maximum number of farmers served in one year by the Team Ag consultant working on the project to date. Qualified individuals include certified nutrient management planners, Certified Crop Advisors and retired conservation professionals. Technicians working under the supervision of qualified individuals could also provide assistance. The Pennsylvania Dept. of Agriculture website currently lists 52 certified nutrient management specialists located in the target counties. An estimated additional 50 qualified individuals located in adjacent counties likely also serve the target counties. Finally, additional qualified individuals not currently providing services would likely enter the market should demand develop.

In conclusion, the most economical scenario is to target 416,797 acres for Nutrient BMP CHALLENGE participation in portions of Lancaster, York, Cumberland, Bedford, Centre, Lebanon and Columbia Counties identified in the Keiser and Associates analysis. These acres have the greatest risk of contributing nitrogen to the Bay based on high corn acreage, high corn yields, high nitrogen application rates and/or high delivery to the Bay due to soil type, slope and proximity to surface water.

6. Recommendations

Based on results and analysis to date, we have the following preliminary recommendations:

Implementation

1. **In collaboration with PDA and NRCS, PA DEP should invest in a new effort to expand the Nutrient BMP CHALLENGE to help achieve WIP goals. PA DEP has strong potential to increase adoption of Penn State recommendations in key corn-producing regions that are most at risk of N losses.** This effort should focus on accelerating adoption of split N applications, with the second application applied as sidedress and using PSNT or chlorophyll meter readings. The BMP CHALLENGE could also support adoption of new technology, including active sensors with potential to more accurately distribute sidedress N based on need within specific areas of the field. If long-term adoption rates are consistent with those experienced to date, an up-front investment of less than $6 million over three years could deliver nearly 20% of Pennsylvania's commitment to N-load reductions on a sustained basis at no additional cost. These advanced technologies are likely to improve efficiencies vs. those experienced to date by further reducing yield and nutrient losses and thus costs per acre and per lb. of N-load reductions.

   In addition to achieving a substantial portion of Pennsylvania's commitment to N-load reductions, this new application of the BMP CHALLENGE in Pennsylvania would provide critical technical assistance to producers with advanced N-management techniques, verify implementation of reduced N use and provide credible estimates of N-load reductions. The effort would also provide important feedback to Penn State and other scientists on the efficacy of current recommendations and implementation of new technology on soils, topography and weather conditions experienced in a critical region of Pennsylvania for sustaining agriculture while reducing impacts on the Bay. In conjunction, qualified crop advisors could also assess and address opportunities to reduce phosphorus and sediment-losses, adding to the potential to increase efficiency and reduce costs.

   This proposed effort would involve approximately 2000 farmers enrolling 50 acres each and 25 crop advisors over three years. The $6 million investment includes a $500 cost-share payment per farmer to accelerate enrollment.

2. **New efforts to expand BMP CHALLENGE participation should exploit the program's unique appeal to producers who fail to adopt practices due to fear of yield loss.** A variety of adoption incentives address the need for technical and financial assistance. However, the BMP CHALLENGE is the only approach that directly addresses the legitimate fear of income loss. This tool can be particularly valuable in situations where widespread participation is necessary to reach resource protection goals. These include current efforts to recruit broad participation in

no till by the North Capitol Resource Conservation and Development Area Council and the Conewago Creek showcase watershed.

3. **Retain key BMP CHALLENGE mechanics moving forward with minor modifications.** BMP CHALLENGE mechanics are attractive to producers and crop advisors, result in high conversion rates to new practices, provide critical technical support and verification, and are delivered cost effectively by Agflex. These should be maintained with ongoing research and development for continuous improvement and addition of new practices. Current mechanics have very high producer satisfaction and new-practice-conversion rates, and are compatible with NRCS programs and nutrient credit trading.

   Given high post-participation adoption rates experienced here, BMP CHALLENGE costs per lb. of N reduced are extremely competitive with alternative practices and are likely close to being optimized at current rates for Mid-Atlantic states. These should be used for implementation and scenario building going forward. Upward adjustments in crop consultant payments made over the course of the project including a flat, per-field fee, with a reduced fee for additional fields at the same farm, probably reflect accurate market price for Pennsylvania. Enrolling multiple fields per farm has potential to reduce consultant costs per lb. of N further. Administrative costs for the guarantee are not likely to have room for reduction without large increases in volume. It is unlikely that other private or public-sector providers entering the market for the services currently provided by crop consultants or Agflex will result in meaningful program cost reduction. Corn prices are the largest single driver of program costs; the greatest potential for cost reductions lie in choosing practices that minimize yield loss.

   Administrative costs for the guarantee are not likely to be reduced without large increases in volume. It is unlikely that other private or public-sector providers entering the market for the services currently provided by crop consultants or Agflex will result in meaningful program cost reduction. Corn prices are the largest single driver of program costs; the greatest potential for cost reductions lie in choosing practices that minimize yield loss.

4. **Additional improvements should include upgrading data collection to include site-specific rainfall amounts, timing and intensity; yield history; soil type and slope; and topographic and location factors needed to allow more extensive data analysis and more precise calculation of N-load reductions.** Post-participation results should also be improved to increase sample size and accuracy.

Policy

1. **In collaboration with partners, build Chesapeake Bay Congressional Delegation support for the guarantee approach in the new Farm Bill.** Farm-bill conservation programs administered by NRCS are the single largest near-term source of funding for the guarantee system. The Nutrient BMP CHALLENGE is an ideal adoption support tool consistent with NRCS EQIP limited-term contracts to provide cost share and technical assistance to overcome barriers including up-front investment costs, learning curve and foregone income/fear of foregone income. This can be accomplished by including specific language in the next Farm Bill or report language directing NRCS to offer the BMP CHALLENGE as an option for farmers. NRCS needs a clear signal that Congress wants the Service to move forward with this option. While there is strong support among individuals within NRCS at the federal, regional and state level, the December 2010 guidance[40] issued by NRCS national agronomist was inconsistent with prior analysis, expert review and USDA FCIC board approval of the single-check-strip approach. The guidance required a minimum of six to seven replicated strips in each field, which is cost prohibitive and unnecessary.

2. **PNR remains a cost-effective practice for a substantial number of acres in comparison to other options and should be considered for corn for grain grown on the most cost-effective acres, i.e., those most at risk of N loss.** Care needs to be taken to position the practice properly to encourage a favorable response from potential participants and other key influencers. Modest cost savings may be obtainable by moving to an estimated-foregone-income-only model if a sufficient number of farmers are willing to accept payments based on our historical results without on-site harvest assessment and check strips, or with a county-average-based net returns adjustment system.

Research

1. **Data are needed on current adoption rates of N BMPs in Pennsylvania.** Current baseline data are lacking on proportion of farmers with voluntary nutrient management plans, conformance of plans to Penn State recommendations and extent of implementation of those plans. Data are needed on nutrient form, application method, and timing and rate of application, as well as use of reduced tillage, cover crops, buffers, filters, drainage management, etc. Without these data, it will be difficult to measure agriculture's progress in BMP adoption or towards Pennsylvania's WIP goal. A recent survey completed in the Conewago Creek Watershed collected some but not all of this information. Results are pending.

2. **Additional investments should be made to identify the most cost-effective practices that still suffer low adoption due to lack of technical support and income protection.** A wide variety of

[40] Widman, N. 2010. *Comparison Plot Layout and Evaluation for BMP and 590 Evaluation, On-Farm Field Trials for 590-Nutrient Management BMP Challenge.* 4 pp.

practices have potential benefit from the BMP CHALLENGE approach, including a number with reduced risk of negative impacts on farmer net returns, including split applications with in-season testing. Given that a great majority of Pennsylvania farmers growing corn for grain do not have fully implemented nutrient management plans compliant with Penn State recommendations, there is fertile ground for many practices in corn. Other crops and livestock systems may also have potential. Additional practices can be identified by working with Penn State and other scientists. Farmer surveys, such as those conducted in the Lower Susquehanna River Basin in 2010-2011 can help determine which additional practices might benefit most from the performance guarantee system. Pilots will then be needed to collect performance data on selected practices. Priority should be given practices with low risk of negative impacts on net returns given the prospects of continued high corn prices.

3. **Further develop and test an alternate adjustment system that would reimburse forgone income based on county-average net returns rather than an individual field. Use of county data would reduce the cost of implementing a check strip and would allow application on a larger scale.**

Appendix 1. Technical memo: *Developing a Systematic Approach to Generating Agricultural Nitrogen Credits from Planned Nitrogen Reductions in Pennsylvania and Evaluating Economic Feasibility*