HCAE Pub 2011-04

Efficiency Pricing, Next Steps

Final Project Report

For the Harry R. Hughes Center for Agro-Ecology

June 23, 2011

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Funding for this research project was provided by the Harry R. Hughes Center for Agro-Ecology, Inc., affiliated with the University of Maryland, College Park through grant moneys from USDA-NIFA and through the General Assembly.

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1. Introduction

This report completes a project aimed at extending and continuing research on unit-based, or efficiency pricing for nutrient pollution reduction in the Chesapeake Bay. Efficiency pricing implies paying a fixed rate for the desired good – in this case, a pound of annual Nitrogen pollution reduction measured either as edge-of-stream or estuarine delivered load. The new Chesapeake Bay Total Maximum Daily Load (TMDL) provides a convenient means to estimate expected nutrient load reductions by way of the modeled physical processes on which the regulation is based.

In prior research (Wieland et al., 2010), we showed that basing payments for pollution reduction practices on their expected performance would generate greater load reductions for any given level of spending than current payment practices. Given on-going efforts to achieve greater pollution reduction in the Chesapeake Bay, it seemed that these findings would have utility to state policy-makers and the interested public. A primary goal of the project, therefore, was to extend the findings of that prior research. In the following section, we describe efforts undertaken to do that.

While considerable effort was employed under the project to extend the idea of unit-based pricing, it is not clear whether those efforts generated broad-based understanding of the concept. If they did, then one is faced with the difficult task of explaining why it has not gained wider support. If they understand that by merely changing the way that we pay for pollution reduction from the targeted practices we can have more of it, but do not adopt that change, policy-makers appear to be pursuing some other goal than maximizing pollution reduction. Alternatively, the concept may not have been explained sufficiently for policy-makers to fully appreciate the benefits.

In addition to extending the idea of efficiency pricing, the project sought to develop a convenient means to communicate price information to buyers and suppliers of nitrogen reduction services for the target reduction practices. Since nitrogen reduction cannot be seen with the naked eye, and since there are a large number of possible implementation practices and farming practices across regions, without some convenient way to know what a given practice is worth on a specific piece of land, efficiency pricing would not be practical. We describe in Section 3, the development of web-based price communication tools and provide links to them.

Another practical issue that might present a barrier to the adoption of a more efficient pollution reduction pricing scheme is whether it would impose additional administrative costs on implementing agencies. The project assessed how current administrative processes might need to change in order to adopt unit-based pricing. In Section 4, we describe current practice for recruiting and monitoring supply of the target BMPs and how that would need to change, given unit-based pricing. It does not appear that significant additional administrative costs would be incurred under unit-pricing.

In a final section, we address the possibility that a shift to unit pricing might engender strategic behavior on the part of operators such that the purchased pollution reduction is not all additional. If operators are being paid for pollution reduction on a unit basis, since more units could be reduced if there was more pollution to start with, an incentive could arise to engage in practices that resulted in higher baseline loads. Clearly, if operators engaged in such practices, their reductions would not all be additional, since they would have shifted their baseline loads higher before implementing the practice. Section 5 discusses research undertaken by Professors Jim Pease and Darrell Bosch (Virginia Polytechnic Institute) to address this issue and their full paper is appended to this report as Appendix 1.

2. Extension and Outreach

The project sought to extend the idea among policy-makers and the interested public that more precisely calculated payments for nutrient reduction practices will improve nutrient reduction yields at available budgets. Toward that end, a number of activities were undertaken, including: eight targeted presentations, five blog posts, and numerous unanswered offer letters. These activities are summarized below.

2.1 Presentations

PowerPoint presentations were developed for seven different outreach endeavors. The eighth was a poster presentation. These endeavors are briefly described below.

2.1.1 **Chesapeake Bay Technical Workgroup 2/1/10**

This workgroup is made up of technical representatives of the Bay Partner jurisdictions. The presentation was shown both on an internet link and before an audience at the Chesapeake Bay Program (CBP) offices in Eastport. In the presentation we took the audience through the benefit of using a unit pricing approach and why this was different than how nutrient load reductions are currently reimbursed. We showed the data files and explained how the variables were being generated. We used graphs to show how things would look if suppliers were lined up efficiently. The questions were good and the crowd seemed to get the general picture.

2.1.2 **Presentation to CBP Scientific and Technical Advisory Committee (STAC) Quarterly Meeting 6/8/10**

This presentation was made to attenders of the summer quarter STAC meeting and attempted to span the topic from marginal pricing to efficiency metrics and from price communication to contract enforcement. Given the operational problem of a small viewing screen, it is not clear how much was communicated. There has been no follow-up from STAC on the concept.

2.1.3 **Board Presentation to the Center for Agro-Ecology 9/13/10**

This presentation endeavored to communicate to the Board of the Harry R. Hughes Center for Agro-Ecology and their guests the basic benefits of shifting the payments system for nutrient reduction BMPs. Unlike the previous presentation, this one did not attempt to squeeze as much detail in as possible, targeting instead the highpoints. Audience interaction indicated some success at communicating the potential benefits of unit pricing. An excellent newspaper article was generated by the Delmarva Farmer, whose editor was in attendance. This presentation was probably also useful for getting a later meeting with the Maryland Department of Agriculture's (MDA) Deputy Secretary for Conservation.

2.1.4 **Presentation to Royden Powell and Louise Lawrence, MDA 11/9/10**

This presentation was made at the request of MDA. Also in attendance was Matthew Schmid, a Governors Policy Fellow. A complete briefing was provided, along with a written set of talking points, a digital copy of the powerpoint presentation, all the data files used to generate the metrics for unit pricing, and other background information. While the presentation extended for two hours and a great deal was discussed, it is not clear what impact the meeting material has had on policy discussions at MDA.

2.1.5 **Waterfowl Festival Funders Breakfast 11/12/10**

This presentation ranged over several environmental topics of potential interest to a group of people who support environmental protection/restoration in Maryland. Among those topics was the importance of economic efficiency for environmental protection which was discussed in conjunction with the difficulty achieving it. Examples of unit pricing were used to drive these points home.

2.1.6 **Maryland Water Monitoring Council Conference 11/18/10**

This presentation was a breakout session that described in general terms how unit pricing could generate greater nutrient and sediment pollution reduction for the same money, using the same BMPs. Riparian buffers were the Best Management Practice (BMP) of focus for this presentation. The audience, which was not particularly numerous, asked interesting questions that indicated that they grasped the basic story.

2.1.7 **Poster Presentation: ACES[1] Conference, Phoenix Arizona 12/6/10**

Although funded under a different project, this poster presentation included a concise description of the benefits of unit pricing, relative to the costs of existing pricing policies for targeted BMPs. The data and graphs in that poster derived from research funded under an earlier HRH Center for Agro-Ecology grant. The conference was on ecosystem services.

2.1.8 **On-Line Presentation to the CBP Forestry Workgroup 2/2/11**

This presentation covered the benefits of unit pricing with respect to total load reductions from riparian buffers. The workgroup asked good questions and seemed to have some interest in the topic. West Virginia and Pennsylvania were particularly interested, but there has been no significant follow-up as of this writing.

[1] A Community for Eco-System Services.

2.2 Blog posts explaining and promoting unit pricing

Over the life of the project, six one to two page essays have been written and posted on the Main Street Economics blog: http://www.mainstreeteconomics.com/spitting.php. These essays promote in simple language, the benefits of unit pricing. This blog receives about 100 hits per month. There has been no feedback on these posts, but they are being read. The posts include:

http://www.mainstreeteconomics.com/spitting1130.php,
http://www.mainstreeteconomics.com/spitting1215.php,
http://www.mainstreeteconomics.com/spitting072010.html,
http://www.mainstreeteconomics.com/spitting120110.php,
http://www.mainstreeteconomics.com/spitting122010.php, and
http://www.mainstreeteconomics.com/spitting032911.html.

2.3 Unrequited offers to present

At the start of this project, offer letters were sent to the Watershed Implementation Plan (WIP) leads for each of the CBP partner jurisdictions except the headwater states. In addition, offers were mailed to specific agencies such as NRCS – MD and to principals of many of the committees that did invite a presentation, listed above. A second offer letter was sent to those same WIP leads several months later. None of the WIP leads responded with a request for a presentation. NRCS – MD did express interest in a presentation, though a date for this was never suggested, after several e-mails.

It was anticipated that, given the new load reduction requirements that are being imposed on jurisdictions through the Chesapeake Bay TMDL, policy makers would be interested in hearing about a means to achieve greater nutrient reduction using existing, proven technologies, just by changing the way that we pay for them. For that reason, our offer letters pointed out that the topic that we wished to present to WIP leads and their teams offered this potential.

The lack of response to our offer letters may just indicate that WIP leads are too busy responding to their assignments to consider alternative mechanisms that have not already been cleared by their superiors. That is, our offer letters did not carry sufficient credibility to convince recipients that this was a technically sound idea worthy of consideration.

An alternative explanation for the lack of uptake from the WIP leads is that costs are not a factor in the development of their WIPs. As there are no economists on any of the WIP teams that we are aware of, it is likely that economic costs are not a significant factor in their efforts. If costs are not a factor in achieving the requirements of the TMDL, it would stand to reason that WIP teams would not be concerned about getting more nutrient and sediment pollution reduction for any given budget.

Ultimately, of course, it is for the WIP leads and other policy-makers to explain why our offer letters were not of interest.

3. Development of a Valuation/Pricing Tool

A key requirement for unit pricing to supply the desired incentive effects for least-cost achievement of nutrient pollution obligations is convenient access to information about the relative values of implementing different abatement practices. In service to that objective, the project developed and made publicly available three pricing tools for two different BMPs: cover crops and riparian buffers.

3.1 Cover Crop Pricing Tool

The Cover Crop Pricing Tool is posted on-line at: http://www.mainstreeteconomics-b.com/covercrops.aspx. This pricing tool generates per acre N load reduction for the entire range of cover crop planting practices, including: time of planting, seed choice and planting method. The value of these practices is dependent on several user-supplied variables, including: whether the field is on the coastal plain or not, previous crop, whether a nutrient management plan is in effect on the field and normal tillage practices there.

When a user defines the characteristics of a field in which she is interested in planting cover crops, she clicks "submit" and a database query generates appropriate estimates for the expected nitrogen load reduction that would be achieved by each of the available cover crop practices on that field. The predicted annual reductions are based on CBP cover crop efficiencies and nitrogen export by land-use and region, calculated as delivered load by the Chesapeake Bay Watershed Model (Version 5.3). In addition to enumerating nitrogen reduction expectations by practice, the pricing tool also factors pounds N reduced per acre by a notional price per pound (in this case, $8.00/lb N). This gives per acre values for N reduction by cover crop practice at that notional price per pound.

3.2 Alternative Cover Crop Pricing Tool

The expected value of different cover crop practices calculated as pounds of nitrogen reduced per acre per year depends upon the coefficients for practice effectiveness and nitrogen export rates. In the example above, we used Chesapeake Bay Watershed Model parameter estimates. Meisinger and Staver (unpublished manuscript), use a much simpler model to estimate load reduction per acre for the same set of cover crop practices. In their unit efficiency matrix, they assume a base loading rate which is then factored according to the prior commercial crop and whether or not manure was applied in the spring. They apply to those nitrogen load export estimates the same reduction efficiencies as used by the CBP.

The pricing tool was adapted to incorporate Meisinger and Staver's unit reduction estimates with a unit value factor and posted at: http://www.mainstreeteconomics-b.com/CoverCropsAlt.aspx. Unlike the previous pricing tool, nitrogen export from crop fields in this example are calculated as edge of stream loads. Because some natural attenuation is expected between the edge of stream and the load delivered to the Chesapeake Bay, edge of stream reduction estimates are larger than delivered load estimates. We apply a notional price of $5.00/lb N reduction in this pricing tool.

To know the value of any specific cover crop practice on any field in the coastal plain[2], a user simply specifies what crop the field was planted in prior to planting cover crops and whether or not manure was applied in the spring. The pricing tool then generates the value of the range of cover crop practices on that acre if nitrogen were prices at $5.00/ lb per year. It displays practice values sorted from most remunerative to least. This alternative tool shows that expected values of applying a practice are clearly dependent on the technical coefficients one uses.

3.3 Riparian Buffer Pricing Tool

The riparian buffer pricing tool is posted at: http://www.mainstreeteconomics-b.com/RiparianBuffers.aspx. In order to know the expected value of a riparian buffer in terms of pounds of nitrogen reduced, one needs to know the hydro-geomorphic region in which the buffer is located, the land use on the land that is converted to riparian buffer, and the land use on the land directly up-gradient from the buffer. The user supplies these parameters from the menu offered in each drop-down box and the pricing tool generates expected nitrogen reductions for both riparian grassed buffers (RGB) and riparian forest buffers (RFB).

The parameters used by the pricing tool are Chesapeake Bay Model (version 5.3) loading rates (delivered loads) by land use and hydro-geomorphic region and reduction efficiencies specified by hydro-geomorphic region and buffer type. The value calculations then factor the difference between the current land use and either RGB or RFB land uses on the acres within the buffer, and add that to the effect that the buffers have on nitrogen export from up-gradient acres.

4. Institutional Impacts

A third focus of the Project was to assess whether or not implementing a unit pricing scheme would impose additional costs on implementing agencies. If calculating the nutrient reduction value of a specific conservation practice under unit pricing required additional activities by the agencies administering the program, then the possibility arises that a unit pricing scheme might carry higher administrative costs than current programs. If, on the other hand, current administrative implementation, certification and payment practices supply all the information that is needed to employ unit pricing, then it is implied that there would be no institutional cost impacts for program administrators.

Below, we consider existing administrative practices for certifying and verifying payments due for cover crops and riparian buffers in Maryland. In particular, we consider the information generated by these administrative practices with reference to the information required for unit pricing. If the information generated by current administrative practices satisfies the information requirements of a unit pricing scheme, then we are saved the trouble of using a time-motion study to evaluate differences in administrative costs.

[2] Meisinger and Staver do not provide export estimates for the non-coastal plain.

4.1 Enrolling and Certifying Cover Crop Acres: (MACS 2010)

In Maryland, cover crops are encouraged through a payment system administered by MDA – specifically, the Maryland Agricultural Cost Share program (MACS). The institutional arrangements for reimbursing the planting of cover crops are described below.[3]

In the spring of the year, information about the current cover crop program is mailed to operators with nutrient management plans. This mailing includes information about payment tiers for different cover crops and planting times, as well as sign-up requirements and schedules. The operator whose name appears on the relevant nutrient management plan is expected to make a decision about whether or not to enroll acres in the cover crop program prior to the end of the scheduled sign-up period. Having a nutrient management plan for agricultural operations is essential to participating in the program and, currently, only acres with a nutrient management plan can be enrolled.

During the mid summer enrollment period, eligible operators come to their district conservation office and enroll a specific number of acres in specified fields. These offers are gathered by district conservation officers and compiled by MACs.

In the fall planting period, the operator notifies district conservation staff what fields have been planted, what crops the cover follows and cover crop seed, planting time and planting method. Fields entered are located on Farm Service Agency (FSA) maps that verify acreage and nutrient management standing. District conservation staff visually confirm at least 20 percent of each operator's plantings, by planting tier. Since the cover crop program provides cash incentives for earlier planting, this may entail several visits to different fields entered by a single operator. On these visits, district conservation staff verify that the field was planted when it was said to be planted and that the crop and planting method are as specified by the operator[4].

In the spring, after the operator has either killed the cover or – in the case of commodity cover crops – allowed it to continue to a crop, he notifies the soil conservation district staff of what he has done and payments are calculated, accordingly. Some spot checking of spring treatments are undertaken by soil conservation district staff.

4.2 A Comparison of Current Practice and the Information Needs of Unit Pricing

As described in Wieland et al., (2010), under CBP modeling the expected nutrient reduction per acre of winter cover crop is defined by:

1) current land use (i.e., cropping system, including nutrient management status),
2) hydro-geomorphic region (coastal plain versus non-coastal plain),
3) manure status,

[3] These arrangements are specific to the 2011 program year, announced in 2010.
[4] Personal communication with Steve Spielman, Talbot County Soil Conservation District.

4) cover crop seed,
5) planting method, and
6) planting time.

We consider each of these factors in terms of current administrative practice, below.

4.2.1 Cropping System and Nutrient Management Status

Under current practice, at the time of the District Conservation agent's first visit, following the planting of the cover crop, it is generally feasible to assess the previous crop. Verifying how that crop was planted poses a requirement for additional information, however. Tillage practices on fields owned by land owners who file a Conservation Plan with their County office can be ascertained with some likelihood, but not all fields will have a Conservation Plan. Moreover, Conservation Plans have a term of ten years and practices and operators can change in ten years.

Whether the prior crop was planted using hi or lo-tillage practices makes a difference under the nutrient reduction calculation of the unit pricing scheme. One means of certifying the tillage practice would be to have this as an information requirement at sign-up. Verifying these self-certifications may, however require a site visit at the time of sign-up to assure the accuracy of those certifications.

Nutrient management plans in good standing are required for entering acres in the cover crop program. This condition is certified by cross-checking the FSA field maps with MDA nutrient management information. All acres entered into the program can therefore be assumed to have nutrient management plans.

4.2.2 Hydro-geomorphic Region

Whether the relevant acres are on the coastal plain or the non-coastal plain is known from the FSA maps used to certify the field location. This satisfies an important information requirement for unit pricing.

4.2.3 Manure Status

Since the existing cover crop program provides payment incentives for enrolling acres that have had a spring application of manure, district conservation staff need to confirm manure status from the relevant field's nutrient management plan. In addition, under the current program there are limitations on allowable cover crop planting practices for acres that have had fall applications of manure. Hence, district conservation staff must also certify this condition.

The means of certifying manure status employed for current cover crop program participants provides the information required for calculating a field's value at a unit price for the pollutant.

4.2.4 Cover Crop Seed

The type of seed used is reported by the farmer and is verified by visual inspection – if not on the first visit, on the spring visit. The type of seed planted is a necessary piece of information for both the current payment system and the unit pricing scheme.

4.2.5 Planting Method

The means by which the cover crop was planted can be ascertained by visual inspection at the first field visit. Planting method is a factor for premiums under the current payment scheme as well as the unit pricing scheme.

4.2.6 Planting Date

Within a narrow range, the planting date can be ascertained at the time of the first field visit. Planting deadlines are an important factor in the current payment system.

4.2.7 Paying for Cover Crops – Using Similar Information Differently

With the exception of tillage practices employed for the previous crop, current cover crop program payments are based on the same factors that would determine an acre's nutrient reduction value under a unit-pricing scheme. These factors drive payments for specific practices by associated premiums, which are added to a base payment for planting cover crops. That is, an operator is offered a base price for planting cover crops, and then is offered a menu of premiums for planting specific types of cover crops in specific ways. The values of these premiums are not determined by the additional nutrient reduction expected from the practice, but by administrators' expectations about what would be needed to motivate the operator to adopt the practice.

Under unit pricing, the value of a specific type of cover crop practice on an acre under a specific land use, in a specific hydro-geomorphic region is determined by Chesapeake Bay model coefficients for loading rates and reduction efficiencies. That is, a price, or, value is applied to the number of pounds of nutrient reduced[5] according to Chesapeake Bay Model expectations. In economic terms, the value is set from the demand side, as opposed to the supply, or cost side.

With the exception of prior crop tillage practices, the factors that determine payment for particular cover crop practices on particular acres are the same for both current cover crop program administration and a unit pricing scheme. The two payment schemes use this similar information differently, however. Under the current program, based on available information, the administrator sums the premiums available to the operator and adds that number to the base payment value. This defines the payment due to the operator.

Under unit pricing, the administrator notes the location of the acre, its land use, and the particular planting practices and seed types employed. The number of pounds of nutrient reduced (by Chesapeake Bay Model coefficients), in conjunction with a value for that pound of reduction,

[5] "Nutrients" in our model are estimated as pounds of nitrogen.

defines the payment.[6] This value can be known by using the cover crop pricing tool described in Section 3.1, above.

4.3. Enrolling and Certifying Riparian Buffers through CREP

About 58[7] percent of the annual riparian buffer plantings in Maryland between 1997 and 2008 received funding support from the USDA's Conservation Reserve Enhanced Program (CREP). Out of a total of 1,317 miles of riparian buffers planted over that period, the CREP program supported 914 miles. Of a total of 25,611 added riparian acres, 15,718 were funded under CREP. Annual additions of both CREP and non-CREP riparian buffers have diminished substantially in recent years.

Water quality benefits of riparian buffers are described in Simpson and Weammert (2007). The percentage reduction efficiencies reported in that publication have been adopted by the CBP in their estimates of the water quality benefits derived from implementing best management practices (BMPs). Riparian buffers are expected to provide a substantial part of the reduction of agricultural non-point source nutrient pollution required under the Chesapeake Bay TMDL.

Implementation of CREP riparian buffer support is managed through USDA's Farm Service Agency and Maryland's soil conservation districts (MDA). The Farm Service Agency provides aspiring adopters with the forms and information that they need to receive support for a riparian buffer. Soil district staff act as technical advisors and ensure compliance.

A land owner interested in receiving support for adopting a riparian buffer is provided the forms and information necessary to enroll acreage in CREP from their FSA service office. The proposed site is mapped using FSA field maps. The landowner then develops a compliant planting plan describing what exactly will be undertaken in the riparian buffer and how it will be managed. This entails developing both a conservation plan and a planting plan, both of which will be appended to the contract between the landowner and FSA for riparian buffer implementation and support.

Once the applicant's conservation and planting plans are accepted, a contract is drawn up which specifies the payments that USDA and MACS will provide in exchange for the land owner implementing those plans. After that contract is signed, the landowner establishes the riparian buffer. He then submits practice cost invoices to FSA for reimbursement. Soil Conservation District staff generally undertake a site visit after the riparian buffer is established to certify that practices were implemented as agreed.

4.4 Enrolling and Certifying Riparian Buffers under Unit Pricing

As noted in Section 3.3, above, Chesapeake Bay TMDL expectations for nutrient load reductions from riparian buffers are based on:

[6] Both the administrator and the operator can easily know the value of a particular practice by employing the pricing tool developed under the current project.
[7] The data in this paragraph are based on DNR's riparian buffer database courtesy of Anne Hairston-Strang.

1) The hydro-geomorphic region in which the buffer is located,
2) The land use on the land that is converted to riparian buffer, and
3) The land use on the land directly up-gradient from the buffer.

Load reduction effectiveness will also depend on whether the buffer is a riparian grassed buffer (RGB) or a riparian forest buffer (RFB).

4.4.1 Hydro-Geomorphic Region

The hydro-geomorphic definitions for riparian buffers under CREP funding follow FSA field map soil types. These soil type categories are different than the hydro-geomorphic categories used by the Chesapeake Bay Model. While soil type is a factor taken into consideration under current administration, it is not tracked according to CBP hydro-geomorphic categories, and, it does not have implications for payments. FSA field maps, therefore, would need to be cross-referenced with CBP hydro-geomorphic maps. This would entail little more than querying a database of CBP hydro-geomorphic regions by FSA field map.

4.4.2 Land Use Conversion

In order to calculate the change in nutrient export owing to the change from a higher polluting land use to lower polluting forest or grassed buffer, it is necessary to know the prior land use on the converted acres. This information is already a part of the planting and conservation plans that prospective CREP participants submit for approval. Those plans are generally verified by field staff.

4.4.3 Up-Gradient Land Use

In addition to the nutrient load reduction achieved by land conversion on the acres shifted to riparian buffer, there is an expected additional nutrient reduction from the overland flow from up-gradient acres. Therefore, land use on up-gradient acres is a significant factor for calculating the unit value of nutrient reduction from riparian buffers. This information is also a part of the information requested in owners' planting and conservation plans.

4.4.4 Valuing Riparian Buffers – Using Similar Information, Differently

CBP hydro-geomorphic regions are not currently a datum associated with the payment system for CREP riparian buffers. This additional piece of information is required for unit-pricing because both the nutrient loading rates for various land uses and the reduction efficiencies of riparian buffers vary across those regions. Using the Chesapeake Bay Model coefficients to calculate nutrient reductions for any combination of land uses, hydro-geomorphic region and buffer type requires that the hydro-geomorphic region of a buffer be known. However, there are low-cost and practical ways to acquire that information.

Other than hydro-geomorphic region, current administrative practice gathers the information required to calculate nutrient load reductions from riparian buffers. Prior land use on the buffer itself and land-use up-gradient from the buffer can be drawn from CREP Conservation Plans. Once all of this information is in hand, it is a simple matter to fill out the required fields in the pricing tool described in 3.3, above, to know the value of the buffer in terms of nutrient reduction.

4.5 Discussion

Our approach to assessing potential differences in the administrative costs of the current CREP and cover crop programs versus expected costs of a payment scheme based on nutrient reduction performance has been to compare the information needs of both systems to see whether these are significantly the same. If they were the same, then expectations for administrative cost differences would be nil.

In making a comparison between the two approaches, it is shown that a single additional datum would be required for each conservation practice. Using Chesapeake Bay Model coefficients to determine the value of cover crop practices requires knowing the tillage practice used to produce the prior crop. This information is not currently collected. Having the operator certify the tillage practices used on fields that are enrolled into the program is one low cost means for obtaining this information. However, verifying those certifications might require an additional site visit by Soil District staff, and those costs could be significant.

In order to calculate riparian buffer nutrient reduction values using Chesapeake Bay Model coefficients it is necessary to know the buffer's hydro-geomorphic region, following CBP categories. Currently, soil type and other geographic conditions of offered buffers are described using Farm Service Agency categories. Since Farm Service Agency field maps are used by the CBP, however, it would be a simple matter to cross-reference any offered field against their CBP hydro-geomorphic categories. The cost of this solution would not be significant.

Although the need for additional information prevents the claim that adopting unit-pricing would carry no additional administrative costs, the significance of the expected additional costs is less clear. As a general principle, verifying claims that carry monetary consequences is useful for maintaining the integrity of a payment system. As pointed out in the following section and in more detail in the appendix, monetary incentives are expected to make a difference in the performance of a unit-based payment system. However, appropriate penalties for misrepresenting tillage practices and low-intensity spot-checking might prove adequate for ensuring desired outcomes.

The additional cost of tracking any offered buffer's CBP hydro-geomorphic status does not appear to be significant.

Given very similar information requirements for existing payment systems and a unit pricing scheme, it appears unlikely that there would be significantly greater costs implementing a unit-based system. The actual calculation of value merely requires collating that information somewhat differently than current methods. However, given the pricing tools, that calculation does not require additional effort. This is the utility of the web-based unit pricing tools.

5. Adverse Consequences

The effectiveness of conservation practices such as riparian buffers and cover crops has been discussed above as the difference between nutrient pollution that would have obtained without the practice and the nutrient pollution that is expected after the practice is applied. Those estimated reductions are assumed to be "additional", in the sense that they would not have occurred in the absence of the practice. In this section, we relax the assumption that load reductions are always additional.

Load reductions achieved by implementing cover crops or riparian buffers may not be fully "additional" if reduction incentives encourage operators to shift to a more polluting baseline practice so that the implementation of the conservation practice can reduce greater pollution export. Thus, if in paying the operator for the number of pounds of nitrogen reduced, an incentive is provided for the operator to adopt a more polluting baseline, then the reductions achieved by the practice are not fully "additional" because loads increased before the reduction happened.

Under the project, Professors Jim Pease and Darrell Bosch of Virginia Polytechnic Institute investigated the issue of baseline setting as it applies to estimating payments offered to farmers for adoption of winter cover crops following summer annual row crops. They evaluated a unit-based payment scheme (Wieland et al., 2010) to determine if it would provide an incentive for strategic behavior in manipulating the baseline, and the extent to which such behavior would reduce the effectiveness or increase the costs of reducing nitrogen loadings.

To test the impact of unit-based payments for cover crops as a conservation practice, Bosch and Pease consider two representative Maryland farms of 2,000 acres, one on the coastal plain and the other on the non-coastal plain. Using University of Maryland crop budgets and product price expectations, they examined outcomes for the representative farms over a range of per pound nitrogen reduction prices, from $1 to $12/lb.

Because of requirements imposed by the existing (Maryland) program, there was no baseline shifting over this range of prices. However, when the requirement that operators have a nutrient management plan in place was relaxed, the authors found that there was baseline shifting on the coastal plain representative farm. This shows the importance of considering the incentives that would be put in play by unit pricing for nutrient load reductions. Baseline shifting is a potential problem, even if it is not binding for the case examined.

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Appendix 1: **Setting Baselines for Water Quality Protection Practices: An Example Based on Cover Crops**

Setting Baselines for Water Quality Protection Practices:
An Example Based on Cover Crops

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April 1, 2011

Final completion report for "Estimating Relative Price Effects Under a Fixed Price Per Unit Pollution Reduction Scheme" subcontracted with Main Street Economics, LLC, 2815 Money Make Road, Trappe, MD 21673.

Setting Baselines for Water Quality Protection Practices: An Example Based on Cover Crops

Executive Summary

Policymakers and water quality program managers are searching for alternatives to reduce nonpoint source pollution from agriculture. The Maryland cover crop program promotes planting cover crops, which will reduce nutrient runoff, in exchange for payments. A cover crop program based on performance incentives (payments for estimated pounds of nitrogen reduction) might increase the nutrient reductions for a given expenditure (Wieland et al. 2010). However, there is the potential for baseline shifting to undermine the effectiveness of performance standards. Baseline shifting might occur when the enrolled manager chooses to change the crop rotation as a result of the cover crop payment and the new crop rotation is more polluting than the one planted prior to the payment. We investigated the issue of baseline setting as it applies to estimating the payments to be offered to farmers for adoption of winter cover crops following summer annual row crops. The analysis was applied to two 2000-acre representative Maryland crop farms: a coastal plain and a non-coastal plain farm. Nitrogen reduction subsidies of $1 to $12 per pound of reduced nitrogen were evaluated.

The non-coastal plain farm was more predisposed to adoption of cover crops than the coastal plain farm due to its higher baseline loadings of nitrogen. Higher baseline loadings meant that cover crops trapped more nitrogen and resulted in higher payments. Nitrogen reduction subsidies of $4 per pound induced wheat cover crop planting in the non-coastal plain. Cover crop planting of the entire acreage occurred for payments of $10 per pound or more. The preferred method of planting was drilling, which is more effective in establishing a stand and trapping nitrogen.

The coastal plain farm adopted cover crops for payments of $7 per pound or more. Maximum adoption was 1,800 acres, with 200 acres left without cover. Due to labor and equipment constraints, no more than 90 percent of the cover acres could be planted by the early or normal deadline leaving a minimum of 200 acres (10 percent of acreage) to be planted by the late deadline or not at all. Late planted cover crops trapped fewer pounds of nitrogen and earned lower payments, which made them unprofitable on the coastal plain farm. The nitrogen reduction payment increased total gross margins on both farms, but relatively more on the non-coastal plain farm.

Baseline shifting did not occur on either the coastal plain or non-coastal plain farm. On either farm, the carryover nitrogen from the summer row crop is the same for rotations with and without a cover crop. This result was due in part to the constraint imposed by the Maryland cover crop program that cover crop payments could be received only when planted after crops having a nutrient management plan. When this constraint was relaxed, baseline shifting occurred on the coastal plain farm but not the non-coastal plain farm. With cover crop payments on the coastal plain farm, the rotation shifted from continuous corn with nutrient management (loadings equal to 17 lbs/acre) to continuous corn without nutrient management (loadings equal to 21 lbs/acre). Under this scenario, overall loadings were reduced with cover crops but less than the credited reduction. Credited reductions are based on the ability of cover crops to reduce loadings

from continuous corn without nutrient management but do not account for the fact that a rotation with more pollution potential has been adopted with the cover crop.

Results demonstrate that baseline shifting with a performance incentive program is not an issue given the current rules for participation in the Maryland cover crop program. However there is potential for baseline shifting when the rules governing N incentive payments are relaxed to allow crops without nutrient management to qualify for planting a cover crop. The potential for baseline shifting does not rule out the use of performance-based incentives for cover crop planting. However, it does point to the need for careful consideration of what rules should govern qualifications for the program and how the baseline should be estimated when calculating N reductions. Perhaps if such a program of paying for performance were implemented, farmers desiring to participate could be asked to submit evidence of crops planted before participation. Estimated loadings from prior years' crops could be used as a baseline for estimating the efficiency of cover crops.

Introduction

Since passage of the Clean Water Act in 1972, policymakers have devised various policies and programs to achieve its water quality goals at the state and Federal level. Current efforts include the establishment of TMDLs (Total Maximum Daily Loads) for waterbodies that are deemed to be impaired. Impaired waterbodies (and their watersheds) are those registering levels of specified pollutants that exceed allowable limits for achieving the designated use(s) of the waterbody. In addition to setting a maximum allowance of the pollutant, a TMDL implementation plan involves developing a process for achieving state water quality standards (USEPA, 1999; National Research Council, 2001). As of the end of 2008, it was estimated that some 34,300 TMDL's had been developed with nearly 70,000 still to be developed (USEPA, 2008).

The largest and most complex TMDL attempted to date involves the Chesapeake Bay and its tidal tributaries, which were deemed to be impaired due to nitrogen, phosphorus, and sediment. The U.S. Environmental Protection Agency (USEPA), in collaboration with the six Bay watershed states (Virginia, Maryland, Delaware, West Virginia, Pennsylvania, New York and the District of Columbia) initiated the process of developing TMDLs for the entire 64,000 square mile watershed (Virginia Department of Environmental Quality, 2010). A maximum allowable loading of nitrogen, phosphorus, and sediment has been developed and allocated among Bay states and major tributary basins. At the jurisdiction level, Watershed Implementation Plans (WIPs) allocated portions of the reduction total to the various source sectors (wastewater, urban stormwater, onsite/septic, agriculture and air deposition). The final TMDL was issued in December 2010, and WIPs present a plan to control pollutants.

Implicit in the development of a TMDL is a progress accountability procedure to insure that scheduled progress is made towards achieving the TMDL allocations. EPA plans include 2-year milestones to assess progress towards reaching the 2025 goals of having sufficient and appropriate practices in place that can be expected to reduce pollutant loadings below TMDL levels. Progress is assessed in terms of the number and type of pollution control practices installed, with the assumption that pollutant loading reductions are directly tied to practices.
In order to evaluate the effectiveness of practices and programs for pollution control at the farm level, a baseline for pollutant loadings must be established. A baseline is an estimate of the amount of pollution that would be emitted in the absence of the practice or program. A baseline is by definition a counterfactual condition, i.e., one that can never be known. Construction of a baseline is a social activity that is subject to the biases of the institution doing the constructing (Bailey et al. 2001). The perspectives of public administration, economics, environmental non-governmental organizations, business, and environmental analysis differ with respect to the goals and processes of environmental remediation (Bailey et al., 2001). Each perspective is likely to result in a different interpretation of the baseline and hence the amount of credit to assign an environmental remediation activity (Bailey et al. 2001).

Bailey et al. suggest that baselines should be constructed in a setting where interests and commitments are made explicit. An environmental organization such as the Framework Convention on Climate Change, which seeks to promote more environmental remediation, would be expected to be more conservative in setting a baseline, meaning that it would tend to ascribe a lower level of pollution in the absence of an environmental remediation effort. Because the baseline is set lower, a unit of environmental remediation is estimated to be less effective and more units of remediation are needed to achieve a desired level of environmental quality. An organization with an agenda of promoting economic growth would be expected to set a baseline with higher levels of pollution in order to justify the need for fewer units of environmental remediation.

Baselines are more difficult to establish for projects which are highly integrated with the larger economic system due to off-site impacts (Chomitz 2002). For example, a project to preserve forests may drive up lumber prices, thereby encouraging more timber exploitation elsewhere. In that case, the baseline should take note of the added timber exploitation due to higher prices that would not have occurred without the induced price increase.

Economic agents may have the opportunity to strategically manipulate the baseline in order to enhance the perceived effectiveness of their environmental remediation efforts. For example, if the agent is paid based on the number of units of pollution abated, it may be to his advantage to adopt more polluting practices for the baseline period than would otherwise be used in order to achieve higher reductions and higher incentive payments. Wieland et al. (2010) found that a performance incentive might increase expected nutrient reductions when performance is paid based on pounds of nitrogen reduction rather than acres of cover crops planted. However, they cautioned that the potential for baseline manipulation to undermine the effectiveness of performance standards must be investigated.

In this paper, we investigate the issue of baseline setting as it applies to estimating the payments offered to farmers for adoption of winter cover crops following summer annual row crops. The method of payment evaluated is a performance incentive: a payment based on the estimated reduction in nitrogen loading achieved by the practice (Wieland et al., 2010). The performance incentive requires that a baseline nitrogen loading be estimated against which the loadings from the crop with adoption of the cover crop can be compared. Such an incentive stands in contrast to the current incentive system of Best Management Practice (BMP) implementation, which assumes that implementation equates to a particular level of environmental performance. While program administrators may attempt to match payment rates with practice effectiveness, it is unlikely that a BMP program can be as efficient as an incentive program in matching payments with N reductions. The objective of the analysis is to determine if there is a potential reward for strategic behavior in manipulating the baseline and the extent to which such behavior would reduce the effectiveness or increase the costs of reducing nitrogen loadings.

Maryland Cover Crop Program

The Maryland Department of Agriculture's Winter Cover Crop Program provides funding for planting cover crops following harvest of summer annual crops, namely corn, soybeans, sorghum, tobacco or vegetables (Maryland Department of Agriculture, 2010a). A cover crop during winter months is a recommended Best Management Practice which may reduce nutrient (nitrogen and phosphorus) and sediment losses from crop cultivation. It serves to hold soil and nutrients in place during the winter months when losses might otherwise occur from runoff or leaching on bare soil. Cover crops are particularly useful in reducing infiltration of nitrogen into groundwater (Staver and Brinsfield, 1998)[8].

In 2010, farmers can receive up to $95 per acre for traditional cover crops that are left unharvested and killed by tillage or herbicide before spring planting. The base payment rate for certified cover crop plantings is $40 per acre, with additional incentives for more desirable practices in terms of type of seed, time of planting, and method of planting. Farmers who agree to withhold fertilization of a "commodity cover crop" until after March 1 receive a payment of $25 per acre plus an additional $10 per acre if the commodity cover crop is rye. Growers can sign up for both commodity and unharvested cover crops and decide on the acreage certified for each option after the crop is established. Over 500,000 acres were approved in the Cover Crop Program in 2010 (Office of the Governor, 2010). Based on historical experience (Table 1), acres actually enrolled are likely to be less than this due to labor and machinery constraints, weather conditions, and changed price outlook at the time the cover crop decision is made.

Table 1. Maryland Cover Crop Program 1998-2008[a]

Year	Available Acres	Acres Offered	Acres Accepted	Acres Paid	Base Payment Rate ($/acre)	Maximum Payment Rate ($/acre)
1998	235,700	145,028	68,410	50,040	20	30
1999	415,000	162,328	161,667	110,605	20	25
2000	291,000	153,479	109,318	68,022	25	25
2001	314,501	157,413	155,706	99,485	20	25
2002	538,000	263,001	217,271	116,711	20	20
2003	479,000	95,487	93,245	29,584	20	20
2004	580,000	106,934	113,522	53,515	20	30
2005	547,000	210,258	205,268	126,245	25	50
2006	499,000	327,405	210,309	173,087	30	50
2007	420,000	258,321	232,676	143,794	30	50
2008	390,000	237,580	230,897	142,347	45	90

[a]Table from Wieland, R. et al. (2010), "Least-cost Supply of Nitrogen Reduction from Two Important Agricultural Non-point Source Best Management Practices in Maryland," unpublished monograph prepared for the Harry R. Hughes Center for Agro-ecology, University of Maryland. Acres refer only to the "non-harvested" or "traditional" cover crop program.

[8] Since the performance metrics of the Maryland cover crop program are defined solely in terms of surface runoff reductions, this analysis will not consider incentives for reduction of pollutant leaching.

Conceptual Model

We assume that a representative grain farm has the objective of maximizing total gross margins from crop production.

where

= total acres of harvested crop c, which may be a spring or fall planted crop. The NS superscript indicates these crops were selected when there was no subsidy available for cover crops.

GR_c = per acre gross revenue from crop c (crop price times crop yield)

TC_c = per acre variable cost of crop c

If a cover crop subsidy program is available, the farmer's objective function is expanded to include the subsidy income from cover crops

where

S = the subsidy received from cover crop.

$CCrop_{cc}$ = total acres of cover crop of type cc (types vary by species, time, and method of planting)

TC_{cc} is the total cost per acre of cover crops

Performance Incentive

The performance incentive is estimated based on the pounds of nitrogen reduced with the cover crop.

TNred = total reduction in nitrogen loading through use of cover crops

p_N = per pound price of nitrogen reduction . p_N may be set by policymakers based on nitrogen reduction goals.

Nitrogen reduction is estimated as the difference between nitrogen loading under a baseline and loading after planting a cover crop.

where NL_c is nitrogen loading from crop c and NL_{cc} is nitrogen loadings from cover crops. NL_{cc} is negative because cover crops remove nitrogen from soil that would otherwise be subject to loss to the environment and hold it in the crop biomass to be used by a subsequent crop.

In (4), the baseline is nitrogen loadings from the optimal set of harvested crops when a cover crop subsidy is not available, while the cover crop scenario includes nitrogen loadings from harvested crops chosen when cover crop payments are available plus loadings from cover crops (which are negative). NL_{cc} depends on the crop type and production practice for the crop grown prior to the cover crop. Farmers could choose a harvested crop type or production practice that is prone to higher nitrogen loadings in order to increase efficiency of the succeeding cover crop in removing nitrogen and thereby the performance subsidy. If this occurs, then

The strategic behavior results in cropping changes that cause the reduction in nitrogen loadings to be smaller than it would be otherwise. Here we label such cropping changes to increase estimated reductions in nutrient losses by cover crops as *baseline shifting*.

However, once the subsidy program is in place, is unobservable. The environmental program manager may choose to use as a proxy for crops the farmer would have planted without subsidized cover crops. In that case,

and because the 1st and 2nd terms on the right hand side are equal, nitrogen reductions simplify to

Estimated nitrogen loading reduction in (7) is larger than in (4) because (7) does not consider the increased nitrogen loading resulting from the farmer's strategic behavior.

Practice Incentive

Subsidy for the practice incentive is calculated as:

where s_{cc} is the per acre payment for cover crop of type cc. Payment per acre may be set based on perceived effectiveness of the particular combination of planting time, species planted, and planting method in reducing nitrogen loss.

Because payments for cover crops are paid regardless of actual reduction in nitrogen loadings, there is no incentive to adjust harvested crops to increase cover crop efficiency as under the performance standard. However, there may be restrictions on types of crops that can be followed by a cover crop. For example, the program might specify that a cover crop can only be planted following a summer annual row crop. If cover crop payments were sufficiently high, farmers might shift out of hay crops into row crops in order to qualify for higher cover crop payments. If row crops are more polluting than hay land, nitrogen loadings could increase with the cover crop subsidy program. Such behavior is not considered in this study.

Empirical Model

Representative farms are evaluated for the coastal plain and the non-coastal plain of Maryland. The coastal plain refers to flat, low-lying areas along the Chesapeake Bay coastline, typically with higher production potential than the upland Piedmont or Ridge-and-Valley regions. Maryland coastal plain counties include Caroline, Kent, Queen Anne's, Talbot, Anne Arundel, Calvert, Charles, Prince Georges, St. Mary's, Dorchester, Somerset, Wicomico, and Worcester[9]. Each representative farm manages 2,000 acres of good quality row crop land. Continuous corn rotations (Table 2) are one-year rotations while corn-soybean and corn-wheat-soybean rotations are two-year rotations. All rotations in Table 2 are considered for the baseline. However, a nutrient management plan is required as a condition of participation in the cover crop program.

Table 2: Crop rotations considered in the study.

Rotation	No-till	Conventional till	Manure	Nutrient Management[a]
Continuous corn	X			
Continuous corn	X			X
Continuous corn		X		
Continuous corn		X		X
Continuous corn		X	X	X
Corn soybean	X			
Corn soybean	X			X
Corn soybean		X		
Corn soybean		X		X
Corn soybean[b]		X	X	X
Corn-wheat soybean[c]	X			
Corn-wheat soybean[c]	X			X
Corn-wheat soybean[d]		X		
Corn-wheat soybean[d]		X		X
Corn-wheat soybean[d]		X	X	X

[a]Nutrient management is required for cover crop participation.
[b]Manure is applied to corn only.
[c]Corn and soybeans are produced with no-till, wheat with conventional till.
[d]Corn and wheat are produced with conventional till, soybeans with no-till.

[9] Although considered as non-coastal plain, fully one-third of Cecil County has coastal plain soils (Frank Coale, fjcoale@umd.edu, personal communication, 13Oct2010.

Crop Yields

Extension crop budgets (University of Maryland Extension, 2010) give planning yields, crop prices, and input costs for typical Maryland field crops. Unfortunately, the planning yields are not distinguished between Coastal Plain and non-Coastal Plain counties, nor do they represent any statistical calculation based on historical yields (Table 3).

Table 3: 2010 University of Maryland Extension Crop Planning Yields (all non-irrigated)

Crop/Rotation	Yield (bu/acre)
Corn Grain, no-till	150
Corn Grain, conventional till	150
Soybeans, full season, conventional till	40
Soybeans, full season, no-till	40
Wheat, conventional till	75
Wheat/soybean double-crop	
Wheat	75
Soybeans	25

In order to estimate yields for the various cropping practice alternatives in this study for Coastal and non-Coastal plain counties, we adopted the method described in the Chesapeake Bay Program Office "Scenario Builder" software (USEPA Chesapeake Bay Program Office,2011) In that document, planning yields for crops planted with a nutrient management plan and not with a nutrient management plan are estimated from the distribution of historic county yields (USDA National Agricultural Statistics Service, 2010). Using county yields from 2000-2009 for coast and non-coastal plain counties, we estimate non-nutrient management planning yields as the 95th percentile of the historical yield distribution, while nutrient management planning yields are the mean of the highest 60% of historical yields. The resulting 2010 target yields for corn and wheat are estimated as shown in Table 4 for nutrient management and non-nutrient management crops within coastal plain and non-coastal plain counties.

Table 4: Estimated 2010 Planning Yields for Coastal Plain and Non-Coastal Plain Counties

	Coastal Plain		Non-Coastal Plain	
Crop	Nutrient Management (bu/acre)	Non-nutrient Management (bu/acre)	Nutrient Management (bu/acre)	Non-nutrient Management (bu/acre)
Corn grain	149.0	155.9	137.3	150.5
Wheat	67.9	71.8	68.1	71.6
Soybeans (full season and double-crop)[a]	36.8		35.3	

.[a] Since the focus of this analysis is nitrogen reduction through cover cropping, soybean yields are assumed to be unaffected with a nutrient management plan

However, with this procedure it is not possible to distinguish full season from double-crop planning yields. Assuming initially that all wheat and barley acres are followed by double-crop soybean plantings, it is possible to estimate a combination of full season and double-crop soybean yields on the remaining acreage that, when multiplied by estimated full season and double-crop acres, are approximately equal to total soybean production[10]. Soybean target yields as estimated by this procedure are presented in Table 5.

Table 5: Estimated 2010 Full Season and Double-crop Soybeans Planning Yields for Coastal and Non-coastal Plain Counties

Crop	Coastal Plain (bu/acre)	Non-Coastal Plain (bu/acre)
Full season Soybeans	42	42
Double-crop Soybeans	30	30

Crop budgets: With the yields estimated above, crop enterprise costs and returns are adapted from University of Maryland Extension budgets (Table 6). The $85 per acre land charge is removed from costs as the farm is assumed to maximize returns to management, risk, and land. Nitrogen application rates are adjusted based upon the rates appearing in the budget (1 lb nitrogen per planned bushel of corn or wheat). Phosphate and potash applications were not adjusted by planned yield for corn, wheat, or soybeans. Manure applications (poultry litter costing $15/ton applied) were allowed up to the phosphate requirement of the crop with consideration for supplemental nitrogen and potash applications. Allowing for nitrogen volatilization with surface application and no incorporation, a ton of litter as applied was assumed to have a plant-available nutrient concentration of 44 lbs nitrogen, 40 lbs phosphate, and 51 lbs potash available to crops during the first year after application (Mid-Atlantic Water Program, Parker, 2006). Finally, the cost of nutrient management planning is estimated as the average farmer cost-share per acre ($2.40/acre) from nutrient management program incentives in 2009 (Maryland Department of Agriculture, 2010b). An explanation should also be offered for the commodity cover-wheat-soybean enterprise budget. We found no convincing data indicating that fall-planted wheat fertilized before March 1 generates a higher yield than the same crop fertilized after March 1. Therefore, we assume that the costs and yields for the two enterprises are equal. This implies, of course, that in the absence of yield variability, the wheat commodity cover crop program promises a higher gross margin than does the conventional wheat-soybean enterprise. Gross receipts and gross margins include only the income from crop sales. Subsidy payments for cover crops are included separately.

Table 6. Estimated Crop Yields, Gross Receipts, Variable Costs, and Gross Margins, Coastal Plain and Non-Coastal Plain.

Crop type	Yield (bu/ac)	Gross receipts[a] ($/acre)	Total variable cost ($/acre)	Gross margin[a] ($/acre)
Coastal Plain				
1. Corn no-till	155.9	617.36	445.78	171.58
2. Corn no-till, NM	149.0	590.04	441.72	148.32
3. Corn conv.-till	155.9	617.36	450.61	166.75
4. Corn conv.-till, NM	149.0	590.04	446.55	143.49

[10] This procedure can hardly be claimed to be precise, but the results are consistent with other available data (University of Maryland, Extension. 2010).

5. Corn conv.-till, NM, manure	149.0	590.04	416.10	173.94
6. Full season soybean-no till	42.0	390.18	267.75	122.43
7. Full season soybean-conv. till	42.0	390.18	317.55	72.63
8. Wheat-soybean	71.0/30.0	634.41	556.18	78.23
9. Wheat-soybean NM	67.9/30.0	618.88	556.94	61.95
10. Commodity cover-wheat-soybean	71.0/30.0	634.41	556.18	78.23
Non-Coastal Plain				
1. Corn no-till	150.5	595.98	440.73	155.25
2. Corn no-till, NM	137.3	543.71	430.77	112.94
3. Corn conv.-till	150.5	595.98	445.56	150.42
4. Corn conv.-till, NM	137.3	543.71	435.60	108.11
5. Corn conv.-till, NM, manure	137.3	543.71	401.09	142.62
6. Full season soybean-no till	42.0	390.18	267.75	122.43
7. Full season soybean-conv. till	42.0	390.18	317.55	72.63
8. Wheat-soybean	71.0/30.0	634.41	556.18	78.23
9. Wheat-soybean NM	67.9/30.0	618.88	556.79	62.09
10. Commodity cover-wheat-soybean	71.0/30.0	634.41	556.18	78.23

[a]Amount includes only the income from sale of crops. Cover crop subsidies are included separately.

Cover crops

In this analysis, a cover crop can be planted following corn or soybeans. Traditional cover crops are not harvested. Traditional cover crop payment rates differ by planting method (drilled or broadcast), timing (early-before October 1, normal-between October 1 and October 15, or late-between October 15 and November 5), and whether harvested or not. Wheat, rye and barley are available cover crop species, but only wheat is considered here as it is most widely grown. Commodity cover crops are harvested and do not receive a premium according to planting date or method. Wheat is viewed by growers as the best option if the crop is to be harvested as a commodity cover crop. For this analysis, it is assumed that commodity wheat cover is planted prior to October 15 and drilled, as these practices result in the best crop stand.

Cover crop establishment costs vary by seeding method (drilled, or broadcast) (Table 7). Costs are obtained from the Cover Crop Cost Efficiency Calculator (Wieland et al., 2010).

Table 7. Cover crop nitrogen removal efficiencies and total variable costs.

	Nitrogen removal efficiency (%)[a]		
	Coastal Plain	Non-coastal Plain	Total variable cost ($/acre)
Wheat, drilled early	31.2	24	33.40
Wheat, broadcast early	26.6	20	33.55
Wheat, drilled normal	28.6	22	33.40
Wheat, broadcast normal	24.3	18	33.55
Wheat, broadcast late	11.4	9	33.55
Wheat commodity	28.6	22	NA[b]

[a]Source: Simpson and Weammert.
[b]Commodity wheat assumed to be drilled by normal deadline. Commodity wheat costs are described in Table 6.

In this analysis, five types of unharvested wheat cover can potentially follow corn or soybeans (Table 5). Commodity wheat cover can follow corn in the corn-soybean-wheat rotation. Unharvested wheat can follow soybean in this rotation; however only late planted wheat is a cover crop option due to the time required to harvest late planted soybeans. The amount of wheat that can be planted by the early deadline is constrained to 70 percent or less of total cover acres, and the maximum planted before the normal deadline is constrained to 90 percent or less of total cover acres. These limitations reflect constraints imposed by limited labor and machinery time during the fall planting period, and are based on reported signup of farmers for early and normal planting deadlines during the 2007 planting year (Wieland et al., 2010).

Table 8. Combinations of cover crops and preceding crops analyzed in the study[a]

Preceding crop	WTDE	WTBE	WTDN	WTBN	WTBL	WTCOM
Corn no-till, NM	x	x	x	x	x	x
Corn conv.-till, NM	x	x	x	x	x	x
Corn conv.-till, NM, manure	x	x	x	x	x	x
Full season soybean-no till	x	x	x	x	x	
Full season soybean-conv. till	x	x	x	x	x	
Wheat-soybean[b]					x	
Wheat-soybean, NM[b]					x	

[a]WTDE (WTDN) = Wheat, drilled by early planting date (normal planting date), WTBE (WTBN) (WTBL) = wheat broadcast early, (normal), (late). WTCOM = wheat cover grown for commodity.
[b]Wheat broadcast for unharvested cover follows double crop soybean.

Baseline nitrogen losses

Baseline nitrogen losses (Table 6) are based on input/output tables of the Chesapeake Bay Model (version 5.3) (Wieland, et al., 2010). As described in Table 6, all crops are assigned nutrient losses for one of three land use categories: nutrient management lo-till, hi-till without manure, and hi-till with manure.

Table 9. Baseline crop nitrogen losses[a]

Crop type	Baseline nitrogen loss Coastal Plain (lbs/ac)		Baseline nitrogen loss Non-Coastal Plain (lbs/ac)	
	Edge of Stream	Delivered	Edge of Stream	Delivered
Corn no-till[b]	15.36	14.16	51.67	27.16
Corn no-till, NM[b]	15.36	14.16	51.67	27.16
Corn conv.-till[c]	23.31	21.32	50.86	23.49
Corn conv.-till, NM[c]	23.31	21.33	50.86	23.49
Corn conv.-till, NM, manure[d]	16.98	15.66	51.67	30.12
Full season soybean-no till[b]	15.36	14.16	51.67	27.16
Full season soybean-conv. till[c]	23.31	21.32	50.86	23.49
Wheat-soybean[b]	15.36	14.16	51.67	27.16
Wheat-soybean-NM[b]	15.36	14.16	51.67	27.16
Commodity cover-wheat-soybean[b]	15.36	14.16	51.67	27.16

[a]Nutrient losses are based on runs of the Chesapeake Bay Model for Coastal Plain or Non-Coastal Plain segments, respectively. Land use categories used to estimate nutrient losses for each crop-tillage combination are reported in the following footnotes.
[b]Losses are based on nutrient management lo-till.
[c]Losses are based on hi-till without manure.
[d]Losses are based on nutrient management, hi-till with manure.

Reduction in nitrogen losses

The reduction in nitrogen loss is equal to the sum of cover crop acres grown times the per acre reduction in nitrogen runoff from each cover crop type.

where $NRed_{rc}$ is the nitrogen reduction per acre of cover crop c grown in rotation r. Base nitrogen losses for the crops in the rotation containing the cover crop (Table 7) are multiplied by the nitrogen loss reduction for the cover crop type (Table 3) times the proportion of the rotation acre that is covered by the cover crop.

Nitrogen reduction payment

A series of payments varying in $1 increments from $1 to $12 per pound is considered.

Results

We considered two scenarios: 1) a ***base scenario*** in which nutrient management is required in order to be eligible for cover crop payments; and 2) an ***expanded scenario*** in which non-nutrient management crops can be considered for cover crop payments as well. The base scenario reflects the requirement in Maryland that a cover crop payment can be received only if the preceding crop was under a nutrient management plan. The expanded scenario examines the effects of relaxing the nutrient management requirement on the potential for baseline shifting.

Base scenario

Crop rotations and total gross margins

On the coastal plain farm, and with nitrogen reduction payments of $6 per pound or less, the coastal plain farm opted to plant conventional-till corn with a nutrient management plan and manure application, but no cover crop (CTCC21) (Table 10). When the payment reached $7 per pound or more, 200 acres remained in CTCC21 while 1,800 acres shifted to conventional-till corn with a nutrient management plan and manure application. Of these 1,800 acres, 1,400 acres were followed by wheat cover drilled by the early deadline (CTCC22), and 400 acres were followed by wheat cover drilled by the normal deadline (CTCC23). Due to the reduced ability of cover crops planted by the late deadline to reduce nitrogen, 200 acres of continuous corn were left without cover crops.

Table 10. Crop Rotations and Cover Crops by Nitrogen Reduction Price: Coastal Plain Farm

Nitrogen reduction.price $/lb	Rotation name[a]	Acres	Acres cover crop
0	CTCC21	2000	
1	CTCC21	2000	
2	CTCC21	2000	
3	CTCC21	2000	
4	CTCC21	2000	
5	CTCC21	2000	
6	CTCC21	2000	
7-12	CTCC21	200	
7-12	CTCC22	1400	1400
7-12	CTCC23	400	400

[a]CTCC21 = Conventional-till continuous corn, NM plan, manure application, no cover.
CTCC22 = Conventional-till continuous corn, NM plan, manure application, wheat cover, drilled by the early deadline.
CTCC23 = Conventional-till continuous corn, NM plan, manure application, wheat cover, drilled by the normal deadline.

On the non-coastal plain farm with payments of $3 per pound or less, no cover crop was planted (Table 11). The base rotation consisted of no-till continuous corn, no nutrient management plan, and no manure application (NTCCNC). For a payment of $4, a cover crop consisting of wheat drilled by the early deadline was planted on 1,400 acres of continuous conventional till corn with a NM plan and manure application (CTCC22). For payments of $5 to $9, 400 additional acres were planted with wheat cover drilled by the normal deadline (CTCC23). For payments of $10 or more, the final 200 acres were planted in wheat cover broadcast by the late deadline (CTCC27).

Table 11. Crop Rotations and Cover Crops by Nitrogen Reduction Price: Non-Coastal Plain Farm

Nitrogen reduction price $/lb	Rotation Name[a]	Acres	Acres cover crop
0	NTCCNC	2000	
1	NTCCNC	2000	
2	NTCCNC	2000	
3	NTCCNC	2000	
4	NTCCNC	600	
4	CTCC22	1400	1400
5-9	NTCCNC	200	
5-9	CTCC22	1400	1400
5-9	CTCC23	400	400
10-12	CTCC27	200	200
10-12	CTCC22	1400	1400
10-12	CTCC23	400	400

[a]NTCCNC = No-till continuous corn, no cover, no NM plan, and no manure application.
CTCC22 = Conventional-till continuous corn, NM plan, manure application, wheat cover, drilled by the early deadline.
CTCC23 = Conventional-till continuous corn, NM plan, manure application, wheat cover, drilled by the normal deadline.
CTCC27 = Conventional-till continuous corn, NM plan, manure application, wheat cover, broadcast by the late deadline.

The non-coastal plain farm was more predisposed to cover crops compared to the coastal plain farm. Cover crops were introduced for a smaller payment on the non-coastal plain farm compared to the coastal plain farm ($4 vs. $7). For maximum nitrogen reduction payments, the non-coastal plain farm planted cover crops on the entire farm compared to only 1,800 acres for the coastal plain farm. Both farms used a drill to plant cover crops, a more effective practice for establishing a stand and retaining nitrogen (Simpson and Weammert, 2007).

This predisposition to cover crops is explained by noting that the non-coastal plain farm has baseline nitrogen losses that are more than three times as high compared to the coastal plain farm. Cover crops trap more nitrogen on the non-coastal plain farm and the farm qualifies for higher payments.

The $7 per pound subsidy raised total gross margins by $5,396 (1.5%) on the coastal plain farm (Table 12). Thereafter, each $1 increase in the subsidy raised gross margins by over $9,000. The subsidy raised returns more on the non-coastal plain farm (Table 13). A $4 subsidy increased returns by $5,000 (1.6%). Thereafter, each $1 increase in subsidy increased returns by about $22,000 to $23,000. Increases in gross margins were larger on the non-coastal plain farm because the farm planted cover crops on all acres and was credited with more nitrogen reductions from cover crops.

Table 12. Farm Total Gross Margins, Nitrogen Loadings, and Credited Nitrogen Reductions: Coastal Plain Farm

Nitrogen Reduction Price ($/lb)	Total Gross Margin ($)	Estimated Nitrogen Loading (lbs.)	Credited Nitrogen Reductions (lbs.)
0	347,880	33,960	0
1	347,880	33,960	0
2	347,880	33,960	0
3	347,880	33,960	0
4	347,880	33,960	0
5	347,880	33,960	0
6	347,880	33,960	0
7	353,276	24,601	9,359
8	362,635	24,601	9,359
9	371,994	24,601	9,359
10	381,354	24,601	9,359
11	390,713	24,601	9,359
12	400,073	24,601	9,359

Table 13. Farm Total Gross Margins, Nitrogen Loadings, and Credited Nitrogen Reductions: Non-Coastal Plain Farm

Nitrogen Reduction Price ($/lb)	Total Gross Margin ($)	Estimated Nitrogen Loading (lbs.)	Credited Nitrogen Reductions (lbs.)
0	310,500	103,340	0
1	310,500	103,340	0
2	310,500	103,340	0
3	310,500	103,340	0
4	315,500	85,979	17,361
5	337,183	81,432	21,908
6	359,091	81,432	21,908
7	380,999	81,432	21,908
8	402,907	81,432	21,908
9	424,815	81,432	21,908
10	446,787	80,502	22,838
11	469,626	80,502	22,838
12	492,464	80,502	22,838

Nitrogen loadings and reductions

Baseline nitrogen loading on the coastal plain farm was 33,960 pounds. Loadings decreased to 24,601 pounds (reduction of 9,359 pounds) for payments of the $7 per pound and more. Larger reductions occurred on the non-coastal plain farm. The baseline loading (103,340 pounds) declined to 85,979 pounds (17,361 pounds reduction) for a payment of $5 and declined further with higher nitrogen payments to a low of 80,502 pounds for a $10 or higher payment.

Expanded Scenario

Under the expanded scenario, payments could be earned with cover crops following crops not covered by nutrient management plans. While this is not allowed under the current Maryland cover crop program, consideration of this possibility shows the potential for baseline shifting under an incentive program with fewer constraints on participation.

Baseline shifting did not occur on the non-coastal plain farm, but did occur on the coastal plain farm. For payments of $5 per pound or less, the farm was planted to a rotation of continuous corn with nutrient management and manure but no cover crop (CTCC21) (Table 14). Nitrogen loadings were 33,960 pounds. With a nitrogen payment of $6 per pound, 1,400 acres were planted to a rotation of continuous corn without nutrient management with a wheat cover drilled by the early deadline (CTCC1). Six hundred acres remained in CTCC21. When payments reached $7 per pound or more, 400 acres were planted to a wheat cover drilled by the normal deadline deadline and 200 acres were left without cover.

With no cover crops, total nitrogen loadings were 33,960 pounds (Table 15). Loadings went down to 32,640 pounds (a decline of 1,320 pounds) with 1,400 acres of cover crops and declined to 32,506 pounds (1,454 pound reduction) with 1,800 acres of cover. Credited nitrogen reductions were higher, however, 10,182 pounds for the $6 payment and 12,848 pounds for the $7 or higher payment. Credited reductions were larger than computed reductions because with cover crops the baseline used to estimate reductions is shifted from CTCC21 to CTCCNC. CTCCNC does not have a nutrient management plan and consequently has higher loadings (21 lbs/acre) than does CTCC21 (17 lbs/acre), which has a nutrient management plan. Reductions qualifying for payment were based on the difference in loadings from the newly installed continuous corn rotations with cover crops and without nutrient management (CTCC1 and CTCC2) versus CTCCNC.

Table 14. Crop Rotations and Cover Crops by Nitrogen Reduction Price on the Coastal Plain Farm under the Expanded Scenario[a]

Nitrogen Reduction Price $/lb	Rotation name[b]	Acres	Acres cover crop
0	CTCC21	2000	
1	CTCC21	2000	
2	CTCC21	2000	
3	CTCC21	2000	
4	CTCC21	2000	
5	CTCC21	2000	
6	CTCC21	600	
6	CTCC1	1400	1400
7-12	CTCC21	200	
7-12	CTCC1	1400	1400
7-12	CTCC2	400	400

[a]Cover crops assumed to qualify for payments when following crops without a nutrient management plan.
[b]CTCC21 = Conventional-till continuous corn, NM plan, manure application, no cover.
CTCC1 = Conventional-till continuous corn with no NM plan, wheat cover, drilled by the early deadline.
CTCC2 = Conventional-till continuous corn with no NM plan, wheat cover, drilled by the normal deadline.

Table 15. Farm Total Gross Margins, Nitrogen Loadings, and Credited Nitrogen Reductions on the Coastal Plain Farm under the Expanded Scenario[a]

Nitrogen Reduction Price ($/lb)	Total Gross Margin ($)	Estimated Nitrogen Loading (lbs.)	Credited Nitrogen Reductions (lbs.)
0	347,880	33,960	0
1	347,880	33,960	0
2	347,880	33,960	0
3	347,880	33,960	0
4	347,880	33,960	0
5	347,880	33,960	0
6	352,150	32,640	10,182
7	364,765	32,506	12,848
8	377,613	32,506	12,848
9	390,461	32,506	12,848
10	403,310	32,506	12,848
11	416,158	32,506	12,848
12	429,007	32,506	12,848

[a]Cover crops assumed to qualify for payments when following crops without a nutrient management plan.

Conclusions

Nitrogen reduction subsidies of $4 per pound induced wheat cover crop planting in the non-coastal plain. Cover crop planting of the entire acreage occurred for payments of $11 per pound or more. A drill was used to plant cover crops, which is more effective in establishing a stand and trapping nitrogen. The coastal plain farm also adopted cover crops, but was less predisposed toward cover crops than the non-coastal plain farm. Cover crops were less profitable on the coastal plain farm because credited nitrogen reductions were lower compared to the non-coastal plain. Adoption occurred for payments of $7 per pound or more. Maximum adoption was 1,800 acres, with 200 acres left without cover due to the reduced ability of late-planted cover crops to trap nitrogen and qualify for nitrogen reduction payments.

The nitrogen reduction payment increased total gross margins on both farms, but relatively more on the non-coastal plain farm. The larger increases occurred on the non-coastal plain farm because of this farm's greater nitrogen loadings and greater capacity to reduce nitrogen with cover crops.

Baseline shifting did not occur on either the coastal plain or non-coastal plain farms. On both farms, the crops planted in the rotation prior to the cover crop had the same nitrogen loadings as the rotation in use when no cover crop payments were available. This result was due in part to the constraint imposed by the Maryland cover crop program that cover crop payments could only be received when planted after crops having a nutrient management plan. When this constraint was relaxed, baseline shifting occurred on the coastal plain farm but not the non-coastal plain farm. With cover crop payments, the rotation shifted from continuous corn with nutrient management to continuous corn without nutrient management. Under this scenario, credited nitrogen reductions were higher than calculated reductions relative to the baseline with no cover crops. The credited reductions were higher because the crop planted in rotation with the cover crop had higher loadings compared to the crop planted with no cover crops.

Results demonstrate that baseline shifting with a performance incentive program is not an issue given the current rules for participation in the Maryland cover crop program. However, there is potential for baseline shifting when the rules governing cover cropping incentive payments are relaxed to allow crops without nutrient management to qualify. The potential for baseline shifting does not rule out the use of performance-based incentives for cover crop planting. However, it does point to the need for careful consideration of the rules governing program participation and how the baseline should be estimated when calculating nitrogen reductions. Perhaps if such a program of paying for performance were implemented, farmers desiring to participate could be asked to submit evidence of crops planted before participation. Estimated loadings from prior years' crops could be used as a baseline for estimating the efficiency of cover crops.

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