# Pursuing Cost Effectiveness for Nutrient Reduction from Riparian Forest Buffers

## Summary

We ask the question with respect to the Chesapeake Bay drainage, "how does one obtain the greatest nutrient load reduction from riparian forest buffers (RFB) for the money that is spent on them?" We answer that question using the same modeled expectations for nutrient loads and reductions that are used to define the Chesapeake Bay's new total maximum daily load (TMDL) regulation. Factoring the load reductions attributable to RFB by the costs of implementing them and sorting the resultant set of unit costs from smallest to largest defines a marginal cost curve for nutrient reduction from the various sources of RFB supply. The marginal cost curve identifies the cost effective delivery of nutrient reductions from RFB.

Given the identification of a cost effective set of RFB, the challenge is then to develop a policy to ensure that new RFB are drawn from that set. We address two different approaches: one in which no price incentives are used, and another in which payments are based on expected nutrient load reduction performance.

## 1. Defining cost effectiveness for riparian forest buffers

Cost effectiveness is an economic concept that, in general terms, relates the amount that one can expect to get of some product to the cost of getting it, at a given level of technology and factor costs. While the general concept is easy to understand, cost effectiveness is predicated on a number of expectations that are useful to consider in terms of our simple definition.

The use of the term "product" in the definition of cost effectiveness implies that it requires a definable product – a desired good or service – that is obtained in the exchange. This product needs to be comparable and quantifiable across different settings. The phrase "cost of getting it" implies that all of the costs of acquiring and possessing the product can be taken into account. And, "at a given level of technology" usually limits the discussion to currently available technology. Factor costs are what must be paid to generate the product.

When we attempt to apply the concept of cost effectiveness to acquiring riparian forest buffers (RFB), the first issue that arises is how to define the product. RFB deliver a number of distinct products, including: nutrient and sediment pollution reduction, habitat and other eco-system benefits for wild plants and animals, commercial forest products, carbon storage, temperature moderation, aesthetic benefits, etc. To the extent that selling any of those products does not diminish the availability of the other products, the sum of the values of each product constitutes the total value of a RFB. While a total value can be of interest, it can also be useful to consider the value of any single product as part of a simpler analysis, or if the analysis is focused on the market for that particular product.

Taking nutrient and sediment pollution reduction as the product of interest, and the Chesapeake Bay region as the area of interest, nutrient and sediment reduction from RFB under different conditions can be estimated as the expected difference in nutrient and sediment export before and after a RFB is installed on a particular piece of land. According to the Chesapeake Bay TMDL, this difference includes the difference between nutrient and sediment loads under the pre-existing land use and the RFB (forested) land use, plus a percentage reduction of expected loads from four up-gradient units of land. The percentage reductions from up-gradient acres are given in Simpson and Weammert, 2010, and vary by hydro-geomorphic region. Nutrient and sediment loading rates are defined by the Chesapeake Bay Watershed Model (Chesapeake Bay Program, 2010) and they vary by land uses and hydro-geomorphic region. Thus, if one knows the land use on both the buffered acres and the up-gradient acres, and if one knows the hydro-geomorphic region, then the expected nutrient and sediment load reduction of an RFB is defined.

Using the parameters described above, it is possible to specify nutrient and sediment load reductions from RFB for every combination of land use and hydro-geomorphic region in the Chesapeake Bay drainage. In areas where the up-gradient reduction percentage is lower and for land uses that are less polluting, load reductions from RFB are lower. In areas with higher up-gradient percentage reductions and under more polluting land uses, RFB load reductions are higher. These differences are obviously important to the question of nutrient reduction effectiveness of RFB.

To determine the cost effectiveness of RFB, it is necessary to consider the costs of achieving nutrient reduction outcomes. For RFB, these costs include installation costs required to create them, maintenance costs, indirect costs (such as water, sunlight or wildlife effects on adjoining acres), and the value foregone by replacing the current land use with a forested land use (i.e., the opportunity cost of the land). If one knows the cost per unit land area of creating and maintaining a RFB, then by dividing that unit land area cost by the unit land area nutrient load reduction one knows the cost effectiveness for nutrient reduction from that RFB, in terms of cost per pound reduced per unit area.

## 2. An Example of RFB Cost Effectiveness in Maryland

Wieland, Parker, Gans and Rigelman, 2010, develop cost effectiveness estimates for riparian buffers in Maryland, using Chesapeake Bay Watershed Model nitrogen (N) load reductions and an average per acre cost for installing and maintaining them. That analysis develops estimates of total available supply of land area using USGS/CBPO estimates of riparian distances by land use and hydro-geomorphic region and the simplifying assumption that all the new buffers will be 100 feet wide. Since the analysis considers both grassed and forested buffers, it also assumes that the current ratio of approximately 2 acres of riparian grassed buffer to each RFB acre will hold across all of this available supply.

The graph, **Pounds of N Reduction from MD RFB @ 60% of Supply**, shows the expected cost of N reduction from RFB under the assumptions stated in the previous paragraph. To create it, 60 percent of the potential riparian buffer area in row crop land uses in Maryland was evaluated in terms of an average cost and expected N reduction, and then that set of values was sorted from lowest to highest[1]. The horizontal axis of the graph shows cumulative N reduction in pounds,

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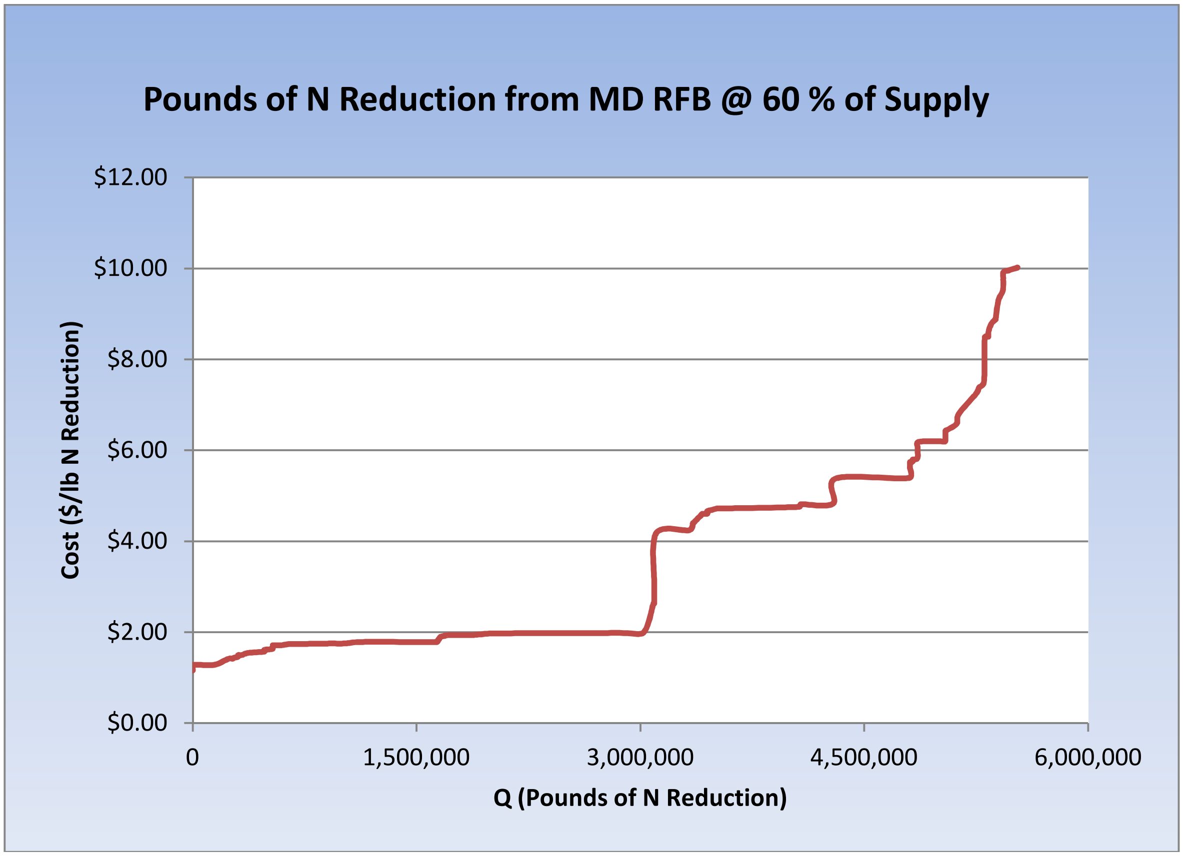
[1] This treatment assumed that for reasons of parcel size and fixed costs 40 percent of total riparian area would never be made available for riparian acres.

and the vertical axis reports the cost per pound required to achieve that cumulative level of N reduction.



The utility of this cost curve for RFB N reduction is that it predicts how the total estimated costs of installing RFB will change for different levels of N reduction, **if the N reduction from RFB were paid by the pound reduced**. If the price per pound N reduced, multiplied by the expected N reduction from a given acre, is marginally greater than the cost of installing a buffer there, the operator is expected to opt into the program. The price per pound would have to rise higher in order to attract suppliers with higher-cost RFB N reduction. Paying for the quantity of N reduced provides an incentive for suppliers to sort themselves as shown in the graph.

A constructed supply curve for riparian buffers is also useful for making cost comparisons between a price per pound[2] payment system and current payment systems. The important support programs for RFB in the Chesapeake Drainage are the Department of Agriculture's (USDA) Conservation Reserve Enhancement Program (CREP) and EQIP. These programs pay a fixed rate per acre for installing RFB. In the absence of any other information about these programs, per acre pricing is as likely to motivate RFB on acres which generate relatively fewer pounds of N reduction as acres that generate relatively more. The absence of a financial incentive to install RFB on higher performing acres deprives one of a basis for expecting that higher performing acres are more likely to be installed.

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[2] This approach is often called "pay for performance" in the economic literature. See Winsten and Hunter, 2011.

The table below is adapted from Table 3.3 in Wieland, Parker, Gans and Rigelman, 2010 and uses the same Maryland data to generate point estimates for the factors that reveal cost effectiveness for N reduction from riparian buffers. Importantly, however, this table includes grassed buffers along with RFB in its estimates. Estimates are based on edge of stream loads. The assumption is retained that 40 percent of the total available acreage at 100 foot buffer widths is not available for reasons of parcel size and cost.

**Expected Riparian Buffer N Reduction by Marginal Price, Total Supply, Costs and Acres**

| | Scenario | Price per Pound | Expected N Reduction (Million lbs) | Total Cost (Million) | Acres Adopted |
|---|---|---|---|---|---|
| 1 | Current Program | $4.42 | 2.51 | $11.10 | 52,637 |
| 2 | N Reduction Supply @ 201,717 available acres | $4.40 | 5.52 | $24.29 | 52.911 |
| 3 | N Reduction Supply @ 201,717 available acres | $1.80 | 2.57 | $4.63 | 20.290 |
| 4 | N Reduction Supply @ 201,717 available acres | $2.02 | 4.92 | $9.95 | 42,021 |

The first row in the table gives the acres of installed riparian buffers (including riparian grassed buffers) based on CREP, 2008 reporting and the annual cost of procuring those acres. Since it was not practical to locate each of these acres spatially, with reference to their own or up-gradient land uses and hydro-geomorphic region, the estimate of N reduction is based on average expected load reductions across all the possible riparian buffer acres.[3] The total amount of N reduction divided into the cost of procuring these riparian buffers generates the average cost per pound of N reduction.

Rows 2, 3 and 4 show the same parameters under a pay for performance scheme based on a fixed price per pound of N reduced, calculated using Chesapeake Bay Model coefficients. In row 2, the marginal cost is similar to the average cost under the CREP program. At that unit cost, the marginal cost function predicts that twice as many pounds of N reduction could be achieved under unit pricing, but that the total cost of this will be more than twice current program costs. However, only about 300 more acres would be required.

Row 3 shows the different parameter outcomes predicted if one sought to acquire the same total amount of N reduction achieved under CREP with a pay for performance scheme. Total costs would be much lower, fewer acres would be required, and the marginal cost per pound of reduction would be much lower.

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[3] With some caveats, this is, basically, what the Chesapeake Bay Watershed Model does when incorporating riparian buffer impacts.

Row 4 shows the different outcomes predicted for unit pricing if one sought to spend roughly the same amount of money currently spent through CREP, under a pay for performance scheme. The closest actual total cost under the modeled unit pricing scheme is about $1 million less than the total current estimated cost of CREP in Maryland. But total N reduction at that total cost is almost double the estimated current achievement, and this is done on 10,000 fewer acres.

While the model described above assumes that current programs do not target riparian buffer acquisition in any way, those programs do in fact target specific areas and specific practices which are thought to have greater N reduction impacts. Such targeting should generate a bias toward higher N reducing acres. This bias will improve cost effectiveness from the case where no effort is made to target payments. But, because some less productive acres are likely to be included in the targeted set and some productive acres will be outside the target set, such an approach cannot be expected to achieve the level of N reduction performance predicted for paying owners a fixed price per pound. In the following section, we discuss options for achieving cost effectiveness for N reduction from RFB.

## 3. Options for Achieving Cost Effectiveness for RFB N Reduction

As noted in the summary at the start of this paper, identifying cost effective N reduction from RFB and achieving the same are two different problems. However, defining cost effectiveness in terms of the unit costs of different levels of total N reduction from RFB provides a standard f or evaluating the achievement of N reduction cost efficiency under different policy options. We assess two different policy options using this standard, below.

The first policy option is to base payment support for RFB on the number of pounds of N reduced by the practice. This can be thought of as the performance incentive or pay-for-performance policy. As has been explained in the preceding sections, such a policy is expected to generate outcomes that parallel the cost effective delivery of N reduction from RFB because the same method for determining cost efficiency is being used to value each additional installation of the practice. There are potential obstacles to this outcome, however.

An underlying requirement for performance-based payment to generate greater cost efficiency is that loads and land uses do not change in response to the performance incentive. When this requirement is not met, it is possible that participants will shift to higher loading land uses, to thereby increase the total value of their RFB. This is referred to in the economics literature as baseline shifting. Baseline shifting is a potential problem that can be addressed in several different ways, but it is something that requires attention before a pay for performance pricing scheme is instituted.

Performance pricing also needs a convenient means for communicating value to potential suppliers. This need can be met nearly costlessly by either developing matrices containing all the payment possibilities for all combinations of land uses and hydro-geomorphic regions, or by putting a user-friendly front end onto a database search algorithm and posting it on the internet. For this to work, however, suppliers need to know the land use on both the RFB and up-gradient areas, and they need to know the hydro-geomorphic region for their RFB area. The agency implementing the program may need to help landowners or operators with this information.

The second option for achieving cost effective performance of RFB is direct targeting without monetary performance incentives. This mirrors current practice for national conservation programs such as CREP and EQIP. Under this option, RFB which generate greater value for conservation expenditure are targeted over RFB which generate less value. Targeting in this instance is effected by giving preference to desired enrollment applications, marketing and outreach. Such practices can improve the cost effectiveness of spending in support of RFB but, unless the targeted set is determined by the technical efficiency matrix described above, it is likely that some less valuable RFB will be in the targeted set and some valuable RFB will exist outside the target set. Moreover, agency staff must work to recruit enrollment, since there is no incentive for preferred RFB adopters to self-select.

Directly targeting RFB enrollment without monetary performance incentives is recommended most substantially by the fact that the policy is already in place. Significant effort has been invested by state and federal agencies to develop ranking schemes for identifying preferred practices and preferred sites for adoption. Staff have been trained to use those schemes. Given that the programs that support RFB are national in reach and support a wider variety of conservation benefits than nutrient and sediment pollution reduction, it could be argued that narrowly focusing payment incentives on the nutrient and sediment performance of RFB based on Chesapeake Bay TMDL coefficients is outside their scope. However, the argument that current policy can provide as cost effective outcomes as performance-based payment schemes is more difficult to make.

## 4. Conclusion

This discussion of improved cost effectiveness for RFB expansion has focused on a single element (Nitrogen) of a larger conservation benefit (nutrient and sediment pollution reduction), which is just one many conservation benefits to RFB. The rationale for this focus is that nutrient and sediment loads are a major factor in the Chesapeake Bay's impairment and that they are targeted in the TMDL regulation. While using national program funding such as CREP to support achievement of specific regulatory requirements does not appear to contravene those programs' enabling legislation, neither does it seem to be officially sanctioned practice.

The TMDL regulation is grounded in pollution load and load reduction expectations specified by the Chesapeake Bay Model. Sorting the modeled expectations for nutrient reductions from RFB, factored by the costs of achieving them and available supply, defines a marginal cost curve for RFB nutrient reductions. This marginal cost curve provides an answer to the question, "where can we get the most nutrient reduction for our money?" Offering RFB adopters a fixed price per pound of nutrient or sediment reduction achieved, based on the same modeled reduction efficiencies is the most straight forward means for achieving the level of cost efficiency shown in the marginal cost curve.

# Literature Cited

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