A Cost-Benefit Analysis

of the 4R Nutrient Stewardship Certification Program*

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Executive Summary

This study is a cost-benefit analysis of the 4R Nutrient Stewardship Certification Program (4R Program), which is governed and guided by the Nutrient Stewardship Council. Certified nutrient service providers (NSPs) agree to advise customers and apply fertilizer according to best management practices (BMPs) and are held accountable via audit. The program is administered by the Ohio AgriBusiness Association who began recruitment and certification of NSPs in 2014.

Given the voluntary nature of the 4R Program, costs entail only the total startup costs of the program, which are estimated to be $350,000 through 2017. Benefits are determined via a previous study, which found that the average Ohio household is willing to pay (WTP) $3.22 for a 1% decrease in harmful algal blooms (HABs) on Lake Erie. The total WTP of all the households in Ohio is $14.67 million for a 1% decrease in HABs. We project that there must be at least a 0.024% decrease in HABs attributable to the 4R Program in order for the benefits to exceed the costs. Using several biophysical models to connect runoff to HABs, we determine that there would need to be a 0.012% decrease in the total spring phosphorous load to accomplish such a reduction in HABs. Such a reduction in total spring phosphorus load could be accomplished in a variety of ways, but modeling a decrease this small in magnitude is not possible with the models currently available. However, current research suggests that if 0.1% of row crop production in Maumee changes practices to include three specific best management practices, then the resulting decrease in HABs could render benefits that exceed the 4R Program costs by two fold.

We use data from a 2015 survey of certified NSPs to assess the odds that such a change in behavior could take place. We also discuss several factors beyond the scope of this study that could alter the benefits and costs estimated in this study such as farmer behavior, benefits to households in other states, and net benefits to NSPs. As the 4R Program is implemented, data on these factors could be collected and analyzed and provide greater precision to the costs and benefits attributable to the program.

Introduction

This report relays the results of a cost-benefit analysis of the 4R Nutrient Stewardship Certification Program (hereafter, the Program), which is governed and guided by the Nutrient Stewardship Council, a diverse set of stakeholders from business, government, university and non-governmental sectors with a common goal of maintaining agricultural productivity while also improving the quality of Lake Erie and its contributing watersheds. The Ohio AgriBusiness Association (OABA), in cooperation with a multi-state effort with sister organizations in Indiana and Michigan, implemented the Program with the goal of maintaining agricultural productivity while also improving the water quality of Lake Erie and its contributing watersheds. The Program was designed to certify nutrient service providers (NSPs) who promote best management practices (BMPs) to achieve cropping system goals while minimizing field nutrient loss and maximizing crop uptake of nutrients. The Program emphasizes nutrient practices that meet the four R's: the right nutrient source at the right rate, right time, and right place with guidance for what is 'right' obtained from land-grant universities' nutrient recommendations.

NSPs who are 4R certified obtain training to learn about these BMPs, and then promise to advise clients in line with BMPs. NSPs who volunteer to participate and become certified must keep accurate records and are subject to mandatory triennial audits. Certified NSPs promise to fully implement the program over a three-year period. Certification requires both initial training as well as ongoing BMP education. As of March 2016, 28 retail facilities had earned certification. These certified facilities provide services to 1.8 million acres, including approximately 1.25 million acres in Western Lake Erie Basin (WLEB) watersheds, and to more than 4,300 farm-based clients, with 60% of the clients located in the WLEB. This represents about 23% of cropland in the WLEB.

Cost-Benefit Analysis: An Overview

A cost-benefit analysis (CBA) is conducted to determine if the benefits of a program, policy or other decision outweigh its costs. While commonly associated with evaluations of larger programs and conducted from the point of view of society as a whole, CBA can also be implemented for private programs that affect small segments of private actors. The goal of CBA is to identify programs that are potentially Pareto improving, that is, where the benefits of a proposed program summed across all affected parties exceed the costs of the program summed across all affected parties.

CBA requires that all costs and benefits be assigned a monetary value. This can be difficult for items not usually associated with a monetary value and for which there is no market in which prices are assigned, such as the presence of a species or the cleanliness of the air. In the case of this report, potential benefits of the Program include the improvement of water quality in Lake Erie, which can yield benefits that may not be fully valued in traditional market settings. In such cases, several techniques can provide estimates of overall values, including surveying people to determine the value they place on such items. Due to many factors, people often (unconsciously) report biased values for such items when directly surveyed. Methods have evolved, however, to counterbalance such biases. This study assigns values based upon survey methodology and employs state-of-the-art techniques designed to offset bias in benefit estimates associated with survey-based techniques.

Program Costs

The costs of the Program are defined as the costs accrued by OABA and partner organizations to establish the Program. Once the Program is established, the fees paid by the NSPs are projected to cover all operational costs. OABA estimates a total of $350,000 in startup costs for the 4R Program. These costs consist of administrative, outreach, legal, education, public relations, marketing, auditor training, and development costs and are spread over four years: $75,000 in 2014, $90,000 in 2015, $85,000 in 2016, and $100,000 in 2017. Fees collected during the startup years are being held as reserves for future years.

A key element of this analysis is that no costs are attributed to NSPs who choose to participate and become certified in this program. Because the program is voluntary, NSPs are assumed to have evaluated internal costs and benefits and found that any firm-level costs of participating and complying with the program are less than the benefits the firm will enjoy. Likewise, no costs are attributed to farms who adopt the altered recommendations of participating NSPs, as these farms are assumed to have evaluated the internal costs and benefits of following their NSPs altered recommendations and either found that the benefits exceeded the costs or found that costs exceeded benefits, which precipitated a switch to an uncertified NSP that could provide services similar those provided by their NSP prior to certification. Therefore, the total cost of the Program is estimated to be $350,000.[1]

[1] If the program were not voluntary, and instead firms and/or farms were mandated to participate in the program, then it would be essential to estimate the costs and benefits each NSP and/or farm attaches to program participation in order to complete an overall Cost-Benefit Analysis.

Program Benefits

For this study, the potential benefits of the program are estimated from responses to a survey in which residents throughout Ohio were questioned about their preferences between competing policies that would reduce the spatial extent of and undesirable outcomes related to harmful algal blooms (HABs) in Lake Erie. Each respondent viewed two possible policies side by side. Each policy featured several attributes: the likely intensity of HABs under the policy, the way the policy was to be funded and implemented, and the financial burden of the policy on the respondent. The likely intensity of HABs was described with a picture showing the spatial extent of algal blooms likely to occur across Lake Erie under the policy. Along with the picture, the estimated reductions (compared to no new policies) in Lake Erie beach closures and fish kills were presented for each policy to demonstrate the change in Lake Erie quality and the level of ecosystem services change expected to accompany each policy. Each policy was also described in terms of the mechanism by which funds would be raised to enact the policy (e.g., income tax, sales tax, fertilizer tax) and the mechanism by which funds would be used to reduce HABs (e.g., fund voluntary programs encouraging farmers to change cultivation practices, fund increased regulation on farm practices, implement a fertilizer tax). Lastly, the financial burden of the policy to the respondent was articulated in terms of the amount the respondent's household would incur per year if the policy were enacted.

Each respondent was shown two possible policies and asked to rate the two policies along with the option of enacting no new policy (see Figure 1 for an example). This was repeated five times with a different pair of policies (including different financial burdens to households) during each repetition. Statistical analyses of the choices made by all the respondents allows us to isolate how much the average household was willing to pay each year to reduce the negative effects of

Figure 1. Example Survey Question Asked of Ohio Residents

	Program A	Program B	Current Program
Annual Cost to your Household	$102	$71	$5
Fish Kills	2,733 fish die annually	4,921 fish die annually	5,467 fish die annually
Number of Annual Beach Closure and Water Quality Advisory Days	45 annual beach closure and water quality advisory days	81 annual beach closure and water quality advisory days	90 annual beach closure and water quality advisory days
Annual Expected Size of Lake Erie Algae Bloom (Satellite Photo)			
Program Details	The government will offer Payment for Ecosystem Service (PES) programs. Farmers who choose to enroll in PES programs will be compensated for implementing practices on their farms that reduce nutrient runoff. The program is funded using **state income taxes**. Given your stated income level, the annual cost of this program to your household will be $102	The government will introduce a new tax on fertilizers. This will reduce nutrient use and nutrient runoff in the watershed. The tax will indirectly affect households through higher food prices. Given your stated income level, the annual cost of this program to your household will be $71	The government will offer Payment for Ecosystem Service (PES) programs. Farmers who choose to enroll in PES programs will be compensated for implementing practices on their farms that reduce nutrient runoff. The program is funded using **state sales taxes**. Given your stated income level, the annual cost of this program to your household will be $5

Please provide a ranking for the above programs where 1=Best, 2=Middle, and 3=Worst

	1	2	3
Program A	○	○	○
Program B	○	○	○
Current Program	○	○	○

HABs on Lake Erie (see Howard, Roe, Nisbet and Martin 2015 for details of statistical methods and hypothetical bias control methods).

The mean value for a 1% reduction in the negative effects of HABs as expressed in the survey is estimated to be $3.22 per household per year across Ohio with a 95% confidence interval of [$1.82, $4.63]. Ohio contains 4,557,655 households (US Census, State Quick Facts, 2009-2013 figure). Assigning the mean value to all households yields an aggregate annual value for a 1% reduction as $3.22 x 4,557,655 = $14.67 million with a 95% confidence interval of [$8.29 million, $21.10 million]. The values placed on reducing the negative effects of HABs was tested and found to be proportionality. That is, for example, we found that the estimated value for a 20% reduction in negative effects was twice as large as for a 10% reduction. In other words, we feel confident ascribing a value of $1.4 million to a 0.1% reduction and $146.7 million to a 10% reduction.

Given this information we now calculate by what percent the effect of HABs must decline in order to generate a benefit of $350,000 as $350,000 (the cost of the Program) divided by $14.67 million (the value of benefits from a 1% decline). This equates to a 0.024% reduction (or, in terms of a fraction, 0.00024) with a confidence interval of [0.0166%, 0.0422%]. In summary, the Program would need to deliver only several hundredths of a single percent reduction in HAB severity in order for the program's benefits to exceed its costs.

Connecting Program Development to Lake Erie HABs

The Program was designed and developed with the hope of reducing HABs and their associated negative consequences. While the Ohio resident survey discussed above allows for estimation of a value for different reductions in the negative effects of HABs, it is more difficult to estimate how NSP participation in 4R Nutrient Stewardship Certification Program affects the intensity of HABs and the magnitude of the related negative consequences.

The chain of events that leads from an NSP's participation in the program to a reduction in HABs and their negative consequences is outlined in Figure 2. The first event in the chain (1) is the costly establishment of the program, which precipitates NSPs' voluntary uptake of the suite of firm-level practices (2). The next link in the chain (3) recognizes that participating NSPs may have already been following some of the practices required of participants,[2] and hence the Program uptake may represent a certification of past implementation of best practices and/or changes to practices precipitated by introduction of the program. The next link (4) recognizes that farmers retain latitude over many nutrient management practices even if their NSP participates in the program. Hence, NSP participation in the program does not guarantee that improved practices will manifest on all acres serviced by the NSP. For example, farmers could change NSPs to one that is not in the program or ignore NSP recommendations that are implemented by the farmer.

[2] Indeed, a 2015 survey asked NSPs certified by the Program "How different would you say the guidelines and recommended practices of the 4R Program are from those that you used prior to committing to the 4R program?" Of the 24 respondents, 21% representing 13% of acres said they were identical and 46% representing 48% of acres said they were very similar (Roe 2015).

Figure 2. Linking Program Costs to Benefits

1. Develop and Offer the 4R Nutrient Stewardship Certification Program	Costs
↓	
2. NSPs voluntarily participate in the Program	
↓	
3. NSP alters recommendations and practices due to Program participation	*
↓	
4. Farmers in LE watersheds change practices due to NSPs' participation	**
↓	
5. Change in amount and timing of phosphorus entering LE watershed waters	
↓	
6. Change in amount and timing of phosphorus transport to Lake Erie	
↓	
7. Change in location, size, intensity and duration of Lake Erie HABs	
↓	
8. Change in negative consequences of LE HABs experienced	Benefits

* These altered recommendations and practices may alter farmer practices outside Lake Erie (LE) watersheds, which may yield additional costs and benefits not accounted for in this analysis.
** Changes to farmer cultivation practices may yield costs and benefits not related to nutrient management consequences which are not accounted for in this analysis.

Link (5) recognizes that changed practices must alter the amount of phosphorus entering relevant watersheds. The efficacy of implemented practices may be sensitive to a number of factors, including the way the farmer executes the practice, the characteristics of the field (soil

type, slope, the presence of drainage tile, proximity to water, etc.) and weather events (the amount and timing of rain). Additional uncertainty accompanies links (6) and (7) as weather events and lake water dynamics can alter the amount and timing of the arrival of phosphorus into Lake Erie and the efficacy of the transported phosphorus in generating HABs of a particular size, intensity and duration. Additional variation and uncertainties are present in the final link that converts HABs into negative consequences such as fish kills and beach closures. For example, weather events can alter the location of HABs, which may be crucial in terms of affecting key fishing regions on the lake or beach closures. It is this reduction in the extent of HAB coverage of Lake Erie and the representative negative consequences articulated in the form of fish kills and beach closures that Ohio residents evaluated in the survey from which we estimate benefits.

Determining the Magnitude of Program Effects that Equates Costs and Benefits

No data yet documents how many farmers altered practices due to NSPs entering the program. Hence, we develop scenarios that would plausibly generate reductions in phosphorus loadings sufficient to deliver a 0.024% reduction in the severity of HABs, which was calculated as the point estimate that yields benefits equal to the costs of implementing the program. Ensemble modeling was undertaken as part of efforts to inform the Annex 4 Report for the Great Lakes Water Quality Agreement (GLWQA) Amendment of 2012. Several Maumee watershed models that were developed by different research groups and calibrated to common historical data were given the same suite of 'what if' scenarios concerning the implementation of BMPs on agricultural land in the Maumee watershed. Each model then simulates how much phosphorus is transported to Lake Erie under a common set of weather conditions (Kalcic et al 2016). Using data from Stumpf et al.

(2012) we estimate that the average size of the bloom within Lake Erie in km^2 is related to TSP (total spring phosphorus load in metric tons accumulated in March – June) as follows:

(1) bloom area (km^2) = 1.41764*TSP - 779.4953 + error,
(0.246) (303.1783)

where the standard errors of each estimated coefficient are presented in the parentheses. This model explains 80.6% of the variation (R^2) of bloom area. Interpreting the output, this means that a one metric ton decrease in TSP is estimated to reduce the size of the bloom by 1.41764 km^2. Given an average bloom size of 816.2 km^2 during this era and an average TSP of 1125.6 metric tons, this yields an elasticity estimate of 1.955, meaning that a 1% reduction in TSP would yield on average a 1.955% reduction in bloom area ($\frac{1.41764 \times 1125.6}{816.2}$). These calculations also suggest that reduction in HAB intensity required to equate program costs and benefits (0.024%) would be generated on average by a 0.012276% reduction in TSP.

Left to be determined is the extent of altered farming practices required to generate a 0.012276% reduction in TSP. Such refined estimates are not possible at this time from existing watershed models. However, we can assess some general magnitudes from the ensemble results presented by Read, Kalcic and Muenich (2016). They find that if producers controlling 25% of all row crop production in the Maumee were to (i) reduce phosphorus application rates by 50%, (ii) apply phosphorus only in the fall and (iii) ensure subsurface placement of phosphorus during application, then there would be about a 6% average reduction in TSP with a standard deviation of about 3.5%. The ensemble model predicts that having 100% of row crops in the Maumee adopt these same three practices would yield about a 22% reduction though the standard deviation increases to about 15%. Making a strong assumption that TSP loadings are linearly related to the

acreage covered by these three practices, if producers controlling 0.1% of acreage adopted these practices then one might expect a 0.024% reduction of TSP, which exceeds the 0.012276% threshold for equating program costs to program benefits by nearly twofold.

Hence, if the Program would influence farmers controlling 0.1% of row crop production in the Maumee watershed to adopt these three practices, then it is plausible that this would, on average, reduce total spring phosphorus loads into Lake Erie. This reduction to the size of harmful algal blooms would be sufficient enough to generate benefits that exceed program costs and to do so by a safe margin (about two fold).

Earlier we noted that the 28 retailers were certified and that they provide advice and services to about 23% of crop acres in the region of interest. Using the information from footnote 2, we project that retailers representing about 61% of acres in the region of interest said that the practices required under the certification program were 'identical' or 'very similar' to their pre-program practices (or that 39% were somewhat similar or somewhat different). This leaves 9% (39% of the 23% of crop acres) of crop acres in the critical watershed areas that will be subject to advice and recommendations from NSPs that are only 'somewhat similar' or 'somewhat different' from those they received prior to certification. In order for 0.1% of row crop production in the Maumee to undertake the three practices from the ensemble modeling scenario, it would require 1 acre of every 90 acres from this 9% to undertake the three practices (1 of 9 acres yields 1% while 1 of 90 acres yields the 0.1% threshold). Recall, this includes a twofold safety margin as well.

Hence, one scenario that plausibly allows Program benefits to exceed Program costs (by a two-fold estimated margin) is that the establishment of the Program presages 1 of 90 acres serviced by NSPs who are substantially changing their practices in order to qualify for the Program to newly

adopt the three key practices outlined above: (i) reduce phosphorus application rates by 50%, (ii) apply phosphorus only in the fall and (iii) ensure subsurface placement of phosphorus during application.

Considerations Omitted from this Analysis

We note that residents of other states may also place positive values on reducing the negative effects of HABs as people from other states and provinces neighboring Lake Erie may also suffer these consequences if they travel to the lake or if they hold intrinsic (non-use) values for the Lake's ecosystem services. For simplicity, and to be conservative in our benefits estimation, we omit such values. Michigan, Ontario and New York residents have alternative Great Lakes that border their states and hence may have lower use rates for Lake Erie, while Pennsylvania has very little land that borders Lake Erie, and the point of contact is on the eastern portion of the lake that is less affected by HABs than the portions of the lake near key Ohio population centers.

Participating NSPs may alter the advice they provide to farmers, and these changes in farmer practices may yield benefits or costs unrelated to the benefits generated via a reduction in the severity and consequences of Lake Erie HABs. For example, affected farmers may change practices on lands that drain to other bodies of water (e.g., much Ohio and Indiana farm land drains to the Ohio River) or may change practices that alter ecosystem services other than those affected by Lake Erie HABs (e.g., carbon sequestration, river and lake sedimentation, wildlife habitat effects). We believe there may be additional net benefits due to these considerations. Estimating

such complex additional considerations is beyond the scope of this study, but suggests the benefits estimated may be a lower bound to true benefits.

We also note that all NSPs involved in this program do so voluntarily despite documented costs of subscribing to the program and altering business practices to implement best practices and accommodate auditing. This means that each NSP has estimated the private benefits and costs of participating and deemed that benefits exceed costs for their individual situation. Hence, another source of net benefits that are ignored in the current analysis are NSPs' benefits in excess of their private participation costs. These could be minor if each NSP's decision was a 'close call' with private benefits only narrowly exceeding private costs, or rather large if firms found participation to be a good deal for them privately. While estimates of private firm-level costs to participate are available, no such information on benefits exists, rendering the calculation of this source of net benefits impossible.

This analysis does not look at the effect of the 4R program on the market for NSPs. Farmers could decide that the practices are not worth it to them and switch to another NSP who is not certified. The magnitude of this effect would depend on the concentration of NSPs in areas where these farmers are located, the location of the farmers (if they are not near the WLEB, then the effect of runoff would be less), and the preferences of the farmers. If post-certification switching away from certified NSPs becomes prevalent, a higher proportion of farmers staying with certified NSPs would have to adopt the three practices mentioned in the phosphorus transport scenario than is estimated above.

Finally, the opportunity cost of the initial $350,000 is not addressed in this analysis. That money could be used for other programs that would lower HABs in the Lake Erie, possibly in a

more effective way. However, since most NSPs and farmers prefer a voluntary program to a tax or other mandatory program, the 4R program may be preferred to other suggested programs.

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