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Executive Summary

Governor Branstad has proposed an initiative that would significantly increase state spending on water quality. This document examines the economic costs and benefits of such a proposal. As with previous work on this topic, this economic evaluation uses the state's Iowa Nutrient Reduction Strategy to measure costs and research results on water quality benefits from Iowa State University's Center for Agricultural and Rural Development.

In doing an economic evaluation of this type, the reader should understand these important points:

1. A calculation of Iowa Nutrient Reduction Strategy costs with current strategies can be determined. The costs in labor, land, machinery and supplies are all well-known factors. There are also scientifically validated studies that show the impact these remedial strategies will have on water quality.
2. While reducing nutrients in surface waters offers benefits, calculating the exact economic value is inherently complex. Few studies are available to estimate the benefits to state residents versus benefits to the nation or world. These studies are based on measures of willingness to pay for improved environmental services and quality. The measures provided here are probably conservative because they exclude those that have yet to be measured or are currently impossible to measure.

Research may develop future technologies that offer similar or enhanced benefits in nutrient reduction at lower costs. For example, some agronomists believe drainage water management technologies may reduce nutrient losses and provide an economic return to producers. However, at this time we cannot include these potential opportunities because the research has yet to be done. Also, more experience with current practices and technologies will yield more benefits.

The Governor's proposal would provide approximately half of the funds required to implement the Iowa Nutrient Reduction Strategy. The rest of the funds would need to come from cost shares from landowners, the federal government, or other third party organizations (such as NGO's). Landowners might be willing to contribute because of reduced soil erosion and improved soil quality or because they prefer this program to possible future regulation. One argument for federal cost is that many of the environmental benefits would be felt downstream of Iowa to the Gulf of Mexico. The benefits of the strategy exceed the costs when these downstream benefits are included. The spending level that the Governor has proposed is approximately equal to the currently identifiable and quantifiable benefits that residents of Iowa would receive from achieving the goals of the strategy. The adoption of this voluntary strategy might also deter potential regulatory approaches.

On an annualized basis, projected spending under this proposal would generate approximately $690 million in economic activity, 1,150 full-time direct employment positions and 2,800 total full-time positions. However, it should be understood that alternative projects and proposals are likely to result in similar economic activity and employment.

Introduction

Governor Branstad has proposed an initiative that would result in a large increase in state spending on water quality. The plan would provide approximately $7.4 million in 2017, this would reach $374.6 million annually in 2049. The purpose of this analysis is to estimate the economic costs and benefits of this proposal.

Methodology

The State of Iowa's Nutrient Reduction Strategy, established in 2013, sets a goal of reducing agricultural nonpoint source generated nitrogen (N) load by 41 percent and phosphorus (P) load by 29 percent in 21 million acres of cropland in Iowa[1]. The Science Assessment of the Iowa Nutrient Reduction Strategy has proposed several different combinations of technologies and farming practices in which these goals could be achieved. Two of these scenarios[2] — labelled NCS1 and NCS3 — are used as the basis for cost estimates presented here.

Iowa State University's Center for Agricultural and Rural Development (CARD) has conducted a number of studies on the benefits of improving water quality in Iowa[3] to Iowa citizens. These benefits include improved water clarity, reduction in soil erosion, control of algal blooms, increases in biological diversity, improvements in recreational opportunities and drinking water supplies and flood control. Research focused on benefits of the Nutrient Reduction Strategy is summarized in the attached report by Hoque et. al. which is used in the current report to estimate the benefit of NCS1 and NCS3 to the citizens of Iowa. The authors of Hoque et al. study makes clear that theirs is a conservative estimate, in part because the value of improvements that could not be estimated is excluded. These exclusions occur because the current state of the science is inadequate to physically measure all of the biophysical changes that would occur due to the technologies and farming practices recommended by the Iowa Nutrient Reduction Strategy. Also, economic measures of these biophysical changes are not currently available. A key missing piece is the health costs, associated with nitrate levels that can occasionally rise above EPA standards.

Programs that improve the quality of water in Iowa benefit Iowans. Improvements to water quality within the state also benefit citizens of downstream states. It has been estimated that Iowa contributes 15 to 20 percent of the nutrients that have created the hypoxic zone ("Dead Zone") in the Gulf of Mexico, which can lead to algal blooms and fish kills.

Surprisingly, there are no available studies on the value that downstream residents place on the likely improvement in water quality in the Mississippi River and the Gulf of Mexico should Iowa and other Corn Belt states adopt practices to reduce the level of nutrients in the water leaving these states. There are two categories of water quality related benefits: (1) benefits from local water quality improvements in downstream states that occur because Iowa has improved the quality of water flowing out of the state, and (2) the benefits that accrue to anyone who values reductions in the hypoxic zone in the Gulf.

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[1] See Strategy, Iowa Nutrient Reduction. "A science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico." *Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, and Iowa State University College of Agriculture and Life Sciences, Ames, IA* (2013).

[2] See Table 5, page 9, http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/NRS2-130529.pdf

[3] See for example http://www.card.iastate.edu/lakes/

Two approaches may help to provide a rough idea of what these two categories of benefits might be. These approaches use values that proxy the missing downstream benefits. The first is based on a methodology designed to provide a measure of the monetary benefit of a specific improvement in water quality for households living in the region where the water is located. This approach is commonly used for situations, like this one, where no other measure is yet available[4]. The second method is based on a study that polled a representative sample of American households and measured their willingness to pay annual taxes to expand the Flower Garden National Marine Sanctuary in the Gulf. The sanctuary is located west of the Dead Zone and has a high level of biological diversity. While neither approach to valuation of the water quality benefits downstream from Iowa is perfect, they both insight into the value of water quality improvements in the affected regions. Further, as described below, the two methods provide similar values, despite very large differences in assumptions and methodologies.

The long-term nature of the Governor's proposal complicates this analysis. It is impossible to predict the water-improving science and technologies that will evolve over the next 33 years. It is very likely that the proposal itself, if implemented, will generate research and technologies that improve efficiencies and reduce costs. Costs will also fall due to the benefits of experience and economies of scale.

An example of a promising technology that is not considered in the cost estimates below is drainage water management. This technology adjusts the level of the water table by controlling the rate at which water drains from the field. This newly emerging technology shows great promise to improve water quality and may also fully pay for itself due to the increased availability of subsurface water in dry years. This technology is not considered in scenarios NCS1 and NCS3. In considering only the technologies that are reported in the two scenarios, this report diverges from the intention of the Governor's proposal in ways that likely increase the projected costs.

It is a challenge to conduct an analysis where spending is at a different level for each of 33 years. Technologies that might be viable with a $347 million budget might not be feasible with a $7.4 million budget. It is standard in this type of analysis to smooth out the spending over the life of the program so that the same amount is available each year. The results in amount is called the equalized annual spending. To calculate this value, we assume that the state issues a bond to be repaid from the proceeds of the program. It then spends the money collected in equal annual amounts over 33 years. This calculation does not imply that bonding is required for the Governor's plan.

This report begins with the calculation of the equalized annual funding that will be available. It then summarizes the cost and benefit information from the studies referred to earlier. It also contains a brief discussion of ways in which the benefits to households downstream of Iowa should be included in the analysis. The last section of the report describes the methodology for calculating the overall economic and employment impact of the strategy.

Finding the Equalized Annual Flow of Funds

First we compute the present value of the sum of all of the proposed annual funding contained in the proposal. This was achieved by assuming that the funds rose from $7.4

[4] See Ge, Jiaqi, Catherine Kling, and Joseph Herriges. "How Much is Clean Water Worth? Valuing Water Quality Improvement Using A Meta Analysis." *Iowa State University, WP* 13016 (2013).

million to $374 million with equal annual increases over a 33-year period. This flow of funds was then discounted using a 2 percent annual interest rate. This is the current coupon rate on bonds issued by the Iowa Board of Regents. The current value of this flow is $4.091 billion.

In order to find the equalized annual value, we begin with $4.091 billion and calculate the size of an annual annuity that depletes this pool of capital over 33 years, again using a 2 percent interest rate. This annualized amount equals $170.54 million.

Tables 1 and 2 show the total estimated costs of two scenarios that the Iowa Nutrient Reduction Strategy describes to achieve the 41 percent (N) and 29 percent (P) reduction targets. These costs are all presented on an equalized annual cost basis. These estimates are subject to uncertainty in part because the science behind large-scale projects to improve water quality is still in its infancy. In particular, programs have not yet been optimized to achieve the greatest improvement at the lowest cost.

Table 1. Projected Annual Costs for NCS1

NCS1	Mil Ac	Estimated N Tons Reduced (1000)	Initial Investment $/a treated	Initial Investment $Million	Equalized Annual Cost $/Acre	Equalized Annual Cost $Million
Nitrogen Optimized	18.9	25			-2	-38
Cover Crops: 60%	12.6	47			25	315
Wetlands: 27% of ag land	7.7	42	316	2,427	10	80
Bioreactors: 60% of drained land	5.9	33	133	790	8	50
Total				**3,217**		**407**
Per acre						**19**

Glossary:

Cover crops: A practice that can increase nutrient efficiency through reduced soil erosion and increased nitrogen uptake when field crops are not actively growing in fields.

Wetlands: New or restored wetlands that intercept water from tiled fields and filter out nutrients.

Bioreactors: Deep trenches filled with a carbon source (e.g., woodchips) that help to denitrify water in field tile drainage, delivering cleaner water to streams and rivers.

Table 2. Projected Annual Costs for NCS3

NCS3	Mil Ac	Tons Reduced (1000)	Initial Investment $/a treated	Initial Investment $Million	Equalized Annual Cost $/Acre	Equalized Annual Cost $Million
MRTN	18.9	25			-2	-38
Cover Crops: 95%	20.0	75			25	499
Wetlands:34% of 103+104	3.9	21	316	1222	10	40
Land retirement: 5%	1.1	12	0	0	201	211
Total				**1,222**		**712**
Per acre						**34**

Glossary:

MRTN: Maximum Return to Nitrogen Rate, determined by the Corn Nitrogen Rate Calculator tool.

Wetlands: New or restored wetlands that intercept water from tiled fields and filter out nutrients.

Land retirement: Enrolling farmland in the Conservation Reserve Program (CRP).

The NCS1 scenario uses cover crops, wetlands and bioreactors. The NCS3 scenario excludes bioreactors, increases cover crops, increases wetlands in two regions of the state and converts 5 percent of cropland to perennials. The estimates are based on a 2 percent annual interest rate and assume that cover crops do not change corn yields. The cost of cover crops is based on air seeding of cereal rye. Note that the Governor proposes to allocate the funding to reduce nutrient discharges from point sources that are not contained in the NCS1 or NCS3. The calculations provided here will be accurate as long as spending on point sources improves water quality as much as the nonpoint sources that are the focus of NCS1 and NCS3.

The Need for Matching Funds

The data in the tables show an annualized total cost of $407 million and $712 million for NCS1 and NCS3, respectively. This is larger than the $170 million that will be available under the Governor's proposal. This means that some type of cost share will be needed to meet the nutrient reduction goals for which these two scenarios are designed. The USDA Natural Resource Conservation Service (NRCS) provided $34 million to Iowa in cost share and staffing in 2015. If funds continue at this level, the total available will be $204.5 million. This is approximately one half of that needed for NCS1. Matching funds from landowners or from beneficiaries outside Iowa will be needed to fill the gap. Landowners might be willing to contribute because of reduced soil erosion and improved soil quality or because they prefer this program to possible future regulation. The federal government might provide additional funds to leverage and encourage efforts of this type. The federal funds might also be justified as a way of paying for the downstream benefits. This will be discussed later in this report.

Benefits of Improved Water Quality to Iowans

Table 3 summarizes the benefits of NCS1 and NCS3 to the citizens of Iowa. The methodology behind these calculations are explained in the attached report[5]. When the literature provides high and low estimates, then the average of these estimates is used. As seen in Table 3, of the benefits that can be quantified and monetized using the best current information, the total benefit to Iowans is $135 million for NCS1 and $203 million for NCS3.

The benefits in Table 3 are smaller than the estimated costs reported in Tables 1 and 2, but are very similar to the proposed spending level of $170 million. Thus, even though all the likely benefits to Iowans cannot be monetized due to current limitations in science and economics, the Governor's proposal provides a level of funding equal to those benefits that can be estimated. Further work is needed on the human health impacts when nitrate levels in small towns or rural wells occasionally exceed EPA limits.

It is not surprising that the total costs are greater than the local benefit. If this were not the case, the state would likely have begun to address this challenge before now. This is a classic example of an environmental externality; the likely solution is to find a way to internalize this externality. The success of this approach will depend in part on the size of the downstream benefits.

Value Outside of Iowa

As was mentioned earlier, there is as yet no available measure of the benefits to citizens outside of Iowa of improved water quality in the Mississippi River or the Gulf. However,

[5] The Hoque et. al. report shows enormous carbon but most of those accrue to people outside of the region so for the time being we abstract from those numbers.

Ge, Kling and Herriges provide a way in which this benefit can be extrapolated from other related valuations. In a paper called, “How Much is Clean Water Worth? Valuing

Water Quality Improvement Using a Meta-Analysis,” the authors use results from more than a hundred academic studies on the benefits of improved water quality to develop a model that can be used to provide a value of water quality improvements in situations where they are related to, but not identical to, the studies used to develop the model.

A key result in this paper shows that for households near a large body of impacted water, a five-point improvement in water quality (from 70 to 75) is worth $673 per year.

The Iowa Nutrient Reduction Strategy is expected to lead to a 1.68-point improvement in water quality of Iowa’s lakes. Using the Ge, Kling and Herriges result, this would be worth $226 dollars to households living near that water.

The water quality improvement downstream from Iowa would be only 15 percent of the 1.68-point improvement in Iowa. Other states would need to adopt a similar plan in order to achieve an Iowa level of water quality improvement in the Mississippi and the Gulf. Taking the value due only to the Iowa program, the benefit would be worth $34 per impacted household per year.

Approximately 37 percent of the residents of Texas, Florida, Louisiana, Mississippi and Alabama live in the Gulf Coast Region[6]. If we assume that 20 percent of the populations of Illinois, Kentucky, Tennessee and Missouri would be impacted, then the total number of impacted households is 11 million. Multiplying this by $34 per household, the total value attributable to the plan from downstream beneficiaries is $375 million per year.

Table 3. Benefits to Iowans of Two Conservation Practices ($Million)

		NCS1		NCS3	
Benefit	**Source**	**Low**	**High**	**Low**	**High**
Reduced Soil Erosion					
	Wetland	40	72	21	37
	Cover Crops	22	32	35	51
Recreation/Wildlife					
	Wetland	3	7	1	4
	Land Retirement			83	83
Water Based Recreation		5	22	5	22
Residential Amenity		17	35	17	35
Drinking Water Purification		0	13	0	13
Total		**87**	**183**	**162**	**245**
Average		**135**		**203**	

Glossary:
MRTN: Maximum Return to Nitrogen Rate, determined by the Corn Nitrogen Rate Calculator tool.
Wetlands: New or restored wetlands that intercept water from tiled fields and filter out nutrients.
Land retirement: Enrolling farmland in the Conservation Reserve Program (CRP).

[6] See Stefanski, Stephanie, and Jay P. Shimshack. "Valuing Marine Biodiversity in the Gulf of Mexico: Evidence from the Proposed Boundary Expansion of the Flower Garden Banks National Marine Sanctuary." (2015).

A second way to arrive at the downstream value is to employ survey methods to determine how much Americans across the U.S. are willing to pay for specific projects to improve water quality, even in cases where some respondents are located near the site and others are not. Stefanski and Shimshack conducted a representative nationwide survey to estimate willingness to pay for water quality improvements in the Gulf of Mexico to be achieved via an expansion in the Flower Garden Banks National Marine Sanctuary. The specific water quality improvement considered in this study may be close enough to provide a general measure of the value of improvement in the health of the Gulf.

The Stefanski and Shimshack results suggested that U.S. households would be willing to pay additional taxes in a range of $35 to $107 per year for this expansion. In this type of study, respondents may overstate their values due to the hypothetical nature of investigation. The authors, therefore, use the lower amount of $35 dollars per household per year. This amount is reduced to $5.25 when one considers only the Iowa-sourced improvement. Multiplying $5.25 by 113 million U.S. households outside of Iowa provides an annual estimated value of $593 million.

Given the wide differences in methods and the general uncertainty there is about this type of analysis, the $593 million value calculated using Stefanski and Shimshack is close to the $375 million found using the Ge, Kling and Herriges method. The average of these two methods is $484 million.

Total Benefits Compared to Total Costs

If we add the $484 million in downstream benefits to the $135 million in Iowa benefits, then the total benefits of $619 million far outweigh the costs of $407 for NCS1. Doing the same analysis for NCS3, the total benefit is $687 and the total cost is $712. This suggests that NCS3 is close to a breakeven.

As mentioned earlier, the benefit estimates are extremely conservative. They measure only those benefits that can be measured. In cases where an assumption was needed, the analysis uses the assumption with the lowest benefit. They also exclude benefits to the farmer of adopting in-field practices such as cover crops — benefits that result from reduced soil erosion and improved soil health. On the cost side, new and promising technologies are excluded as are the benefits of scale and experience. These costs will also come down as individuals associated with implementation optimize spending to achieve the greatest reduction or the lowest cost in each farm-specific scenario. Therefore, it is safe to conclude that the total benefits of the proposal exceed the costs for NCS1 and possibly for NCS3.

Internalizing the Downstream Externalities

The results suggest that the Governor's proposed spending plan provides approximately as much in benefits to the citizens of Iowa from meeting the targets of the Iowa Nutrient Reduction Strategy. However, the strategy is estimated to cost about twice as much as the available funds. If matching funds can be found, for example, from the federal government, then the cost-benefit ratio would change accordingly.

Impact on Employment and Economic Activity

If fully funded, the Iowa Nutrient Reduction Strategy will require labor to plant millions of acres of cover crops, and build thousands of wetlands and bioreactors. The income earned by those involved in this activity will generate additional income to those providing inputs to these sectors and to retailers, restaurants and service workers who rely on economic activity in rural areas. However, it should be understood that alternative projects and proposals are likely to result in similar economic activity and employment.

The U.S. Forest Service developed an economic model called IMPLAN to evaluate the direct and total impacts of this type of activity. For state and local impacts, it considers jobs, labor income, value added and output derived from these activities. The IMPLAN model was used to evaluate the economic impact of a series of water restoration projects of the type envisioned here. This work was conducted in the counties of Lemhi and Custer in Idaho from 2008 to 2013 and involved activities such as reduced erosion and riparian and fish habitat restoration. These activities are very close to the wetland and bioreactor work discussed earlier[7]. The model was also used to measure the economic multiplier and labor impacts of specific crops in Nebraska in 2010. One of these crops is called "other hay" to differentiate it from alfalfa hay[8] and can be used as a proxy for cover crops. This "other hay" crop has a yield per acre of only 1.5 tons and has a value added equal to the total value, indicating that it is a very low input crop. This other hay crop also has some of the lowest labor and economic multiplier impacts. The multipliers for this other hay crop are used for the impact of cover crops below.

The IMPLAN results are provided only for NCS1 because benefits of this alternative clearly exceed the costs. These results are presented in Table 4 below and show that the $444 million in total spending under this program would create $691 million in total economic activity, $173 million in direct labor income and $250 million in total labor income. A total of 1,149 full-time positions would be required for the preparation of wetlands, construction of bioreactors and the planting of cover crops. The total number of jobs direct and indirect is 2,801.

Table 4. Economic Impact of NCS1

	Direct	Total
Economic Impact of Wetlands Under NCS1		
Output ($)	80,000,000	107,323,225
Value Added ($)	33,830,640	49,149,962
Labor Income ($)	30,729,410	38,749,227
Employment	554	826
Economic Impact of Bioreactors Under NCS1		
Output ($)	50,000,000	67,077,016
Value Added ($)	21,144,150	30,718,726
Labor Income ($)	19,205,881	24,218,267
Employment	346	516
Economic Impact of Cover Crops Under NCS1		
Output ($)	315,000,000	516,600,000
Value Added ($)	100,227,273	216,490,909
Labor Income ($)	123,494,318	187,711,364
Employment	248	1459
Total Economic Impact of Cover Crops Under NCS1		
Output ($)	445,000,000	691,000,241
Value Added ($)	155,202,063	296,359,597
Labor Income ($)	173,429,609	250,678,858
Employment	1149	2801

[7] See http://headwaterseconomics.org/land/reports/idaho-restoration-impacts
[8] See agecon.unl.edu/7e55f58f-4829-4413-bf.