Water Quality in Ohio

A Cost-Benefit Analysis

Scioto Analysis
Economics | Public Policy

Executive Summary

Harmful algae blooms are polluting Ohio's waterways, making them unsafe for recreation, decreasing property values, and leaving the state with millions of dollars in cleanup costs. In this cost-benefit analysis, we project the impact of expansions to the "H2Ohio program," a program designed to combat this problem of harmful algae blooms.

The current H2Ohio program has been successful in reducing the amount of phosphorus in Ohio's waterways. We evaluate proposals to expand the H2Ohio Voluntary Nutrient Management Program to more counties and to increase the payment provided to farmers to participate in the program. We evaluate the costs of the program in marginal excess tax burden caused by using these funds as payment and the benefits in the form of increased property values, increased recreation, and decreased cleanup costs.

As more counties become eligible to enroll in the voluntary nutrient management program, we project the present net benefit of the program to exceed $2.3 million. If the program were to be made available to the entire state and phosphorus reductions remain high, the present net benefit of the program could be as high as $12.8 million.

1 Defining The Problem

The surface water in Ohio is too dirty. Ohio lags behind other states in water quality, trailing only Florida in the total cost associated with water pollution and ranking fourth worst in per-capita water pollution costs (Figure 1). In 2011, the water pollution cost the average Ohio resident $219 compared to only $139 for a resident of the average state.[1]

One major impact due to poor water quality, harmful algae blooms (HAB), has cost the state of Ohio over $800 million since 2010 in cleanup costs.[2] This year's harmful algal bloom in Western Lake Erie was the sixth worst in the last two decades

1. Mairi-Jane V Fox and Jon D Erickson, "Genuine economic progress in the United States: A fifty state study and comparative assessment," *Ecological Economics* 147 (2018): 29–35.

2. Environmental Working Group, "The High Cost of Algae Blooms in U.S. Waters," 2020, https://www.ewg.org/research/high-cost-of-algae-blooms.

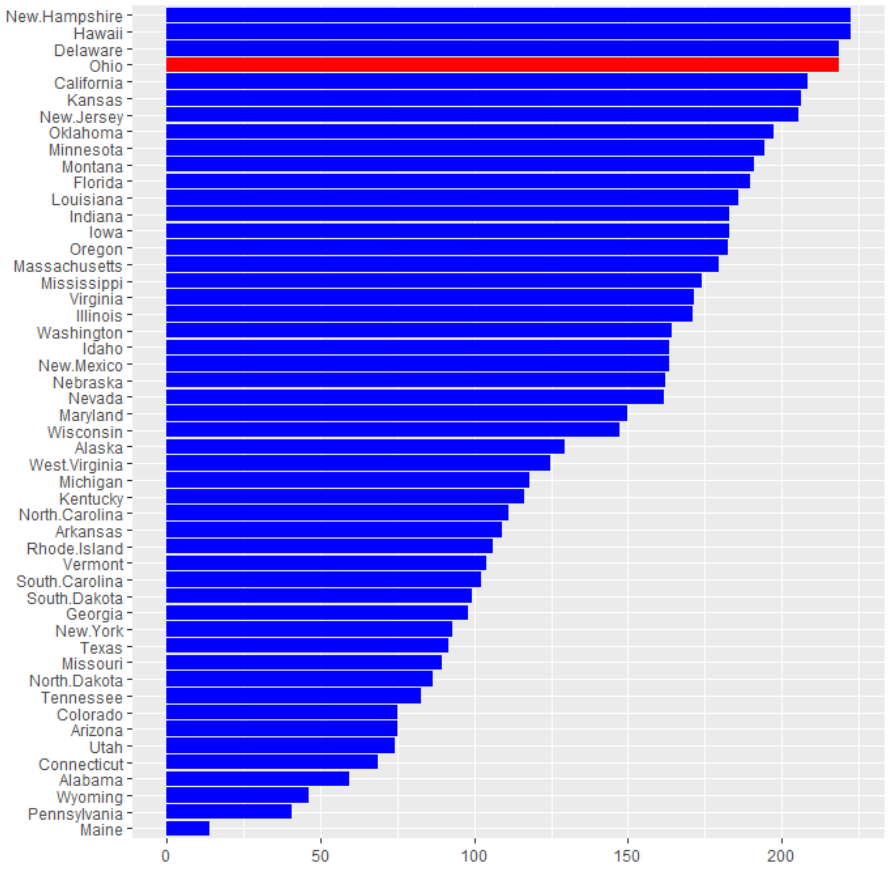

Figure 1: Per-Capita Water Quality Costs (2011 $'s)

and it has stuck around much longer than in previous years, still remaining even through November.[3]

2 H2Ohio

In 2019, the state of Ohio began the H2Ohio program to clean up Ohio's waterways.[4] The program is designed to improve Ohio's water quality through a range of approaches.

3. NOAA, "NOAA Western Lake Erie Harmful Algal Bloom Seasonal Assessment," 2022, https://nccospublicstor.blob.core.windows.net/hab-data/bulletins/lake-erie/current/bulletin_current.pdf.

4. Agriculture Ohio Departments of Natural Resources and Environmental Protection, "H2Ohio," 2022, https://h2.ohio.gov/.

It includes programs to remove lead pipes, dedicates funds for the monitoring of important watersheds, and offers subsidies to farmers who participate in various nutrient reducing programs.

This report focuses on the impact of voluntary nutrient management programs. The goal of a voluntary nutrient management program is to reduce the amount of fertilizer that farmers apply to their crops. This will maximize the efficiency of the fertilizer and reduce the amount of runoff that leaks nutrients into the water, providing less nutrients for algae in streams, rivers, and lakes.

In order to create a voluntary nutrient management program, farmers are responsible for testing their soil and finding out the optimal amount of fertilizer to apply. This can be done by completing the Ohio nutrient management workbook made available by Ohio State University,[5] by working with a certified advisor, or independently. These plans need to be approved by local Soil Water Conservation Districts along with annual nutrient application records in order to ensure the plan is being followed.

One reason farmers have not gone about implementing nutrient management strategies by themselves is because they do not reap the majority of the benefits, which accrue to people outside of the farm itself. By offering a subsidy reducing the barriers to developing and implementing a voluntary nutrient management program, the state can theoretically bring private benefits in line with public benefits. This will increase total surplus and increase the benefits received by non-farmers by more than the cost of the subsidy.

In economic theory, this is an example of a market failure due to an externality. Figure 2 visualises this concept. We expect the market to internally reach an equilibrium where the marginal private costs (MPC) are equal to the marginal private benefits (MPB). Because there is a social benefit, it would be better for society if prices in this market were set such that the marginal private costs equaled the marginal social benefits (MSB). A subsidy is a way for policymakers to shift the market to this preferred equilibrium.

5. The Ohio State University, "Nutrient Management Plan (NRCS 590)," 2020, https://agbmps.osu.edu/bmp/nutrient-management-plan-nrcs-590.

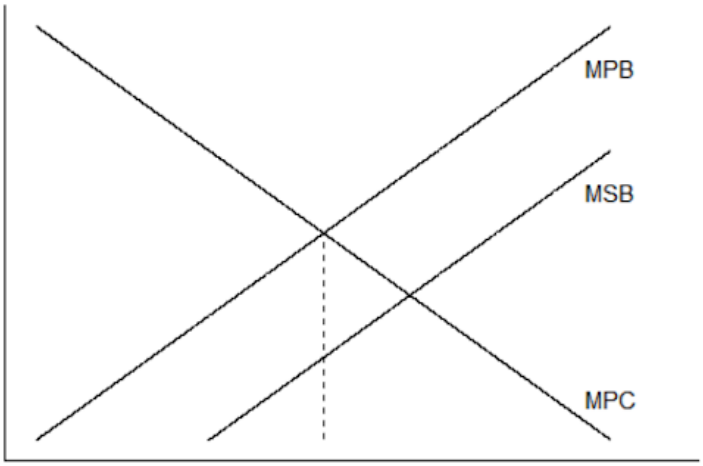

Figure 2: Market Failure Theory

3 Policy Alternatives

Previously, the H2Ohio voluntary nutrient management program was open to farmers from 14 counties in Northwestern Ohio, where water flows into the Western Lake Erie basin. Currently the program is set to expand to 10 additional counties in the Huron, Maumee, and Sandusky river watersheds. Under the current system, farmers are able to receive up to $10 per acre from the state of Ohio for implementing a voluntary nutrient management program.

One change we will analyze is what happens if we choose to **expand the program to the entire state of Ohio**. This approach is a natural extension of the original program, but there are some differences in implementation of a scaled-up program worth mentioning. First, the current counties that are eligible for this program represent a large portion of all the farmland in Ohio. There are plenty of farms in the rest of the state, but there are fewer of them per county than in the pilot counties. On average, the 14 pilot counties have almost twice as many acres of cropland compared to the rest of the state.[6]

The rest of the state is also part of a different watershed. The 14 counties already eligible and the 10 counties that are scheduled to be added all are part of watersheds

6. USDA Ohio Field Office, "County Estimates," 2021, https://www.nass.usda.gov/Statistics_by_State/Ohio/Publications/County_Estimates/index.php.

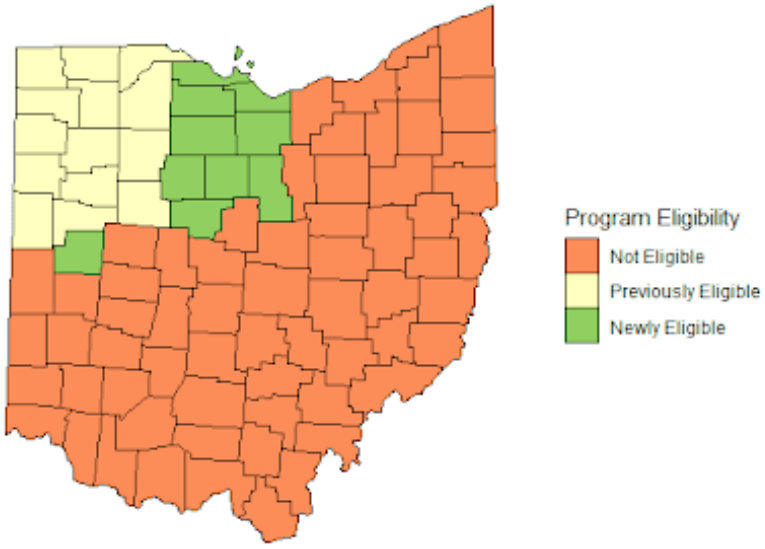

Figure 3: H2Ohio Voluntary Nutrient Management Plan Eligibility

that flow into Lake Erie. In most of the rest of Ohio, water flows into the Ohio river and eventually to the Mississippi. We assume that these water systems will provide benefits in a similar way to Ohioans, but they are not exactly the same. For instance, local trends in recreation and property values could cause benefits from clean water to be higher or lower in different parts of the state.

We also model what would happen if the **subsidy per acre was increased**. In particular, we model what happens when the subsidy is raised to $20 and $40 per acre. The logic behind raising the subsidy is that higher subsidies will provide a better incentive for farmers to opt into the program and will increase participation. Using data from the U.S. Department of Agriculture, we estimate that in the 14 pilot counties roughly 36% of eligible acres of farmland was enrolled in the program and completed a voluntary nutrient management program.[7,8]

Below are the four alternatives we consider in this cost-benefit analysis.

7. Office, "County Estimates."

8. Agriculture Ohio Departments of Natural Resources and Environmental Protection, "H2Ohio Accomplishments for Fiscal Year 2022," 2022, https://h2.ohio.gov/wp-content/uploads/2022/09/H2Ohio-Annual-Report-FY22-Final.pdf.

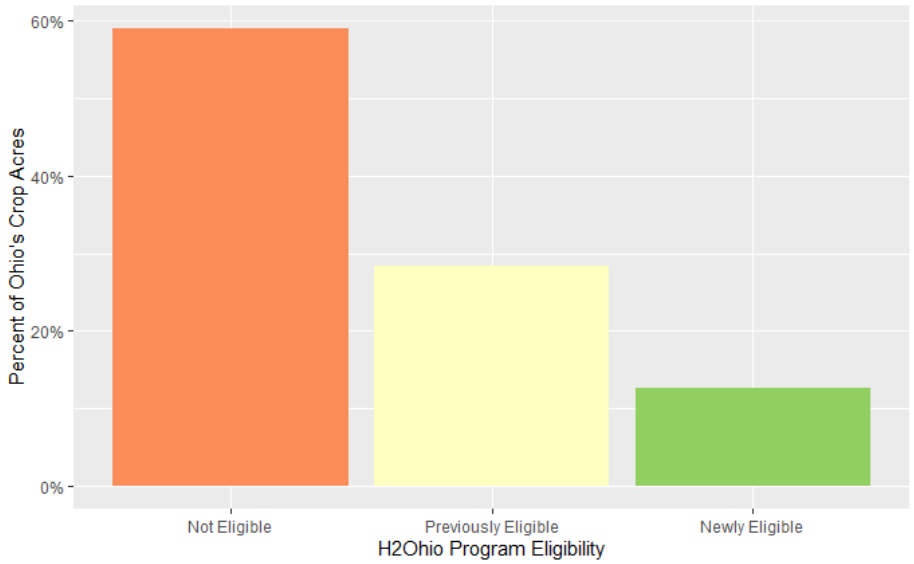

Figure 4: Ohio Cropland by Potential Program Eligibility

- **10-County Expansion (Status Quo)** The H2Ohio voluntary nutrient management program is expanded to 10 new counties in Northeastern Ohio and farmers receive $10 per acre enrolled in the program. We assume the percentage of potential acres enrolled in the new counties is equal to the percentage of enrolled acres in the pilot counties.
- **Entire State Expansion** - The H2Ohio voluntary nutrient management program is expanded to include every county in the state of Ohio and farmers receive $10 per acre enrolled in the program. We assume the percentage of potential acres enrolled in the new counties is equal to the percentage of enrolled acres in the pilot counties.
- **10-County Expansion + Increase per-acre subsidy to $20** - The H2Ohio voluntary nutrient management program is expanded to the ten expansion counties, but farmers now receive $20 per acre enrolled in the program.
- **10-County Expansion + Increase per-acre subsidy to $40** - The H2Ohio voluntary nutrient management program is expanded to the ten expansion counties, but farmers now receive $40 per acre enrolled in the program.

Doubling the subsidy is unlikely to double participation in a voluntary nutrient management program. This is because the second $10 per acre is less valuable to a

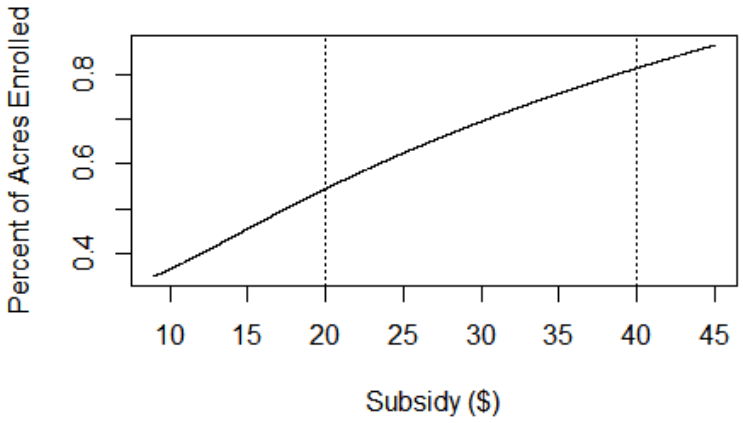

Figure 5: Expected Percentage of Eligible Acres Enrolled

farmer than the first $10, as further reduction in fertilizer use yields lower marginal profits for farmers as farmers have to find new ways to cut fertilizer use. Because of this phenomenon, we model a diminishing marginal increase in program participation with greater subsidy amounts. We model this as a relationship between subsidy and enrollment where doubling the amount of the subsidy results in only a 50% increase in acres of farmland enrolled in the program. Under this assumption, raising the subsidy to $20 and $40 would result in 54% and 81% of potential acres being enrolled respectively.

4 Benefits

The main benefit we anticipate from increased enrollment in nutrient management programs is the social value of improved water quality as the result of reduced amounts of phosphorus runoff. The monetized benefits of better water quality include increases in property values, increased recreation, and less spending on algae bloom cleanup.[9]

In order to model these benefits from improved water quality, we rely on some

9. Apoorva M Sampat et al., "Valuing economic impact reductions of nutrient pollution from livestock waste," *Resources, Conservation and Recycling* 164 (2021): 105199.

Table 1: Monetized Benefits of Phosphorus Reductions

Impact Category	Economic Loss ($/kg)
Property Value	$25.9
Recreational Activities	$45.4
Lake Cleanup	$3.0
Total Monetized Loss	$74.5

assumptions. First, we assume that all phosphorus being removed is "excess" and deteriorates water quality. The Canadian government reports that historically, the Western Lake Erie basin has taken in almost 3,500 tons of phosphorus annually between 2011 and 2020.[10] Given that the state of Ohio end of year report for 2022 claims that the H2Ohio program was responsible for removing 100 tons of phosphorus, it is likely that all of the phosphorus removed is excess.

Additionally, given that Sampat et al. used data from Wisconsin to get estimates for the value of excess phosphorus reduction, we need to adjust for regional price parity. The Bureau of Economic Analysis releases regional price parity figures which we use to adjust for differences in prices between states.[11] Finally, we should mention that the researchers actually measured the losses associated with decreases in water quality, so we assume that improvements in water quality would have benefits that are equal in magnitude to loss due to deterioration of water quality. Because people are risk averse, it is often the case that their willingness to pay for preventing losses is higher than their willingness to pay for equivalent improvements. We explore this phenomenon in more detail in the sensitivity analysis section.

5 Costs

For the policy alternatives we consider in this analysis, the proposed program is a subsidy from the state. Because these funds are raised through taxes, the marginal excess burden of taxation is the primary economic cost of this program. The marginal

10. Government of Canada, "Phosphorus loading to Lake Erie," 2021, https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/phosphorus-loading-lake-erie.html.

11. BEA, "Regional Price Parities," 2020, https://www.bea.gov/news/2021/real-personal-consumption-expenditures-and-personal-income-state-2020.

excess burden of taxation represents the economic loss associated with raising taxes in order to fund a program. Counting the whole subsidy as a cost would be inappropriate because a subsidy is just a transfer of funds from the government to an individual. However, there is loss of economic activity from raising taxes to fund the program that come mostly in the form of distortions in labor and consumer markets from income and sales taxes. This cost is captured by the marginal excess burden of taxation.

Boardman et al's Cost-Benefit Analysis: Concepts and Practice estimates that the marginal excess burden of taxation is between 17% and 23%, depending on if a program is funded via sales or income tax respectively. We should mention that the program is actually structured so farmers receive between $2 and $10 per acre. We assume that farmers will receive the maximum value of the subsidy for each acre, a conservative assumption that gives us a high-end estimate of the cost of the program. Because the H2Ohio program is funded entirely through the general revenue fund, we expect that the marginal excess burden of taxation will be 17%.

We choose not to consider other potential costs such as the costs of soil testing and the time that farmers would have to spend preparing the voluntary nutrient management programs because this is a voluntary program. If it was compulsory, then we would want to account for the fact that farmers would be spending their resources on this project, but the fact that individuals have to opt into this program means that they are making a profit-maximizing decision to participate. The added upfront costs (and potential future benefits) are all internalized by the farmers who choose to participate, and therefore do not represent costs to society.

6 Discounting

In cost-benefit analysis we are concerned with not just the present conditions, but with how costs and benefits accrue over time. Discounting into the future allows us to more accurately describe the tradeoffs and better understand the long term efficiency of a proposal. The way the H2Ohio subsidies are structured, participants receive $2 per acre upon approval of their voluntary nutrient management plan and $2 per acre annually for four years. Following the Washington State Institute for Public Policy, we set our discount rate at 3.5%.[12]

12. WSIPP, "Overview of WSIPP's Benefit-Cost Model," 2020, https://www.bea.gov/news/2021/real-personal-consumption-expenditures-and-personal-income-state-2020.

7 Results

Table 2: Cost-Benefit Results (thousands of kg / millions of $)

Alternative	Phosphorus Removed	Social Benefits	MEBT	Net Benefits
10-County Expansion	40.5	$3.0	$0.7	$2.3
Whole State Expansion	229.7	$16.8	$3.8	$13.0
10-County Expansion + $20 Subsidy	85.6	$6.3	$2.2	$4.1
10-County Expansion + $40 Subsidy	183.9	$13.5	$8.3	$5.2

Under each policy alternative, we expect the benefits to outweigh the costs. Expanding the program to the entire state has the highest net benefit because it incorporates the largest number of acres and we assume that the phosphorus reduction is consistent across the state. We find the lowest net benefit when we increase the subsidy up to $20 per acre. Because we discount future costs, The diminishing returns of increased coverage are still efficient, but having to pay everyone the increased subsidy when many farmers would already enroll in the program is costly. However, if the goal of the program is to remove as much phosphorus from the water as possible, then increasing the subsidy amount might still be worth considering.

8 Sensitivity Analysis

In order to test the sensitivity of results to inputs, we make some assumptions about the possible range of values for variables in our cost-benefit model. In our model, there are three important variables to consider: the percentage of eligible acres that are enrolled in a voluntary nutrient management program, the amount of phosphorus removed per acre on average, and the exact value of the marginal excess burden of taxation.

First, we assume that the percentage of eligible acres enrolled in voluntary nutrient management programs follows a normal distribution where the mean is the expected percentage enrolled based on the amount of the subsidy and the standard deviation is 0.058. Defining the standard deviation somewhat arbitrarily allows us to estimate the likelihood of different outcomes. Here the standard deviation was chosen such that in the $40 subsidy case, the 99th percentile outcome is 99% coverage. It is technically possible to observe cases where we have over 100% coverage, but these are extremely

unlikely and it is possible to imagine a world where at this level of subsidy farmers would buy new land specifically to enroll it in this program and receive the subsidy.

Next we assume that the amount of phosphorus removed per acre is normally distributed with mean 0.097 and standard deviation .0194. This setup is chosen such that the standard deviation is one fifth of the variance. Unlike the coverage, we do not have any natural benchmarks to aim for with the variance assumption.

We assume that the marginal excess burden of taxation is uniformly distributed between 17% and 24%. This is because we do not entirely know the source of the taxes that fund this project, so it follows that the marginal excess burden of taxation should lie somewhere between its two extremes.

Finally, we add an assumption that the benefits received from improving water quality are less than the damages associated with a corresponding loss in water quality. To represent this, we randomly multiply the benefits by a random variable uniformly distributed between 0.5 and 1. This means that in the worst case scenario, individuals would be willing to pay only half as much for improvements in water quality and in the best case scenario they would be willing to pay the same amount.

In order to produce interval estimates for the net benefits under each policy alternative, we perform a Monte Carlo simulation with 10,000 replications. In each replication of the simulation, we realize one of each random variable according to their distributional assumptions, and substitute them into our cost and benefit equations.

Table 3: Monte Carlo Results (millions of $)

Alternative	5th Percentile	95th Percentile
10-County Expansion	$0.6	$2.8
Whole State Expansion	$3.2	$15.4
10-County Expansion + $20 Subsidy	$0.5	$5.1
10-County Expansion + $40 Subsidy	-$2.3	$6.9

9 Scaling

One drawback of the distributional assumptions we make in our sensitivity analysis is that good outcomes and bad outcomes are equally likely. As programs like this grow in scale, we often find diminishing returns. This was captured to some extent by the fact that as the subsidy increases there are diminishing returns to the number of enrolled acres, but our models assume that the same reduction of phosphorus per acre is consistent across the entire state. There is no evidence to suggest that the reduction in phosphorus per acre would decrease for any particular reason, but recognizing that as programs scale they tend to become less efficient is an important consideration for policymakers.

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