

# AN EXAMINATION OF LEVELS OF PHOSPHORUS AND NITROGEN IN THE CHESAPEAKE BAY BEFORE AND AFTER THE IMPLEMENTATION OF THE CHESAPEAKE 2000 PROGRAM<sup>1</sup>

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*Voluntary environmental programs (VEPs) are becoming an integral part of environmental regulation today, but they show mixed results as to whether they can replicate the kinds of successes to which traditional regulatory action can boast. This study looked at one major VEP, the Chesapeake 2000 Program, and its effect on two major pollutants entering the Chesapeake Bay watershed: phosphorus and nitrogen. The study found that while the program did not significantly impact the Bay's overall health, when impact events like hurricanes were removed from the regression model, the program did significantly lower amounts of phosphorus and nitrogen entering the Bay. This research supports the current literature regarding VEP effects, as well as the types of characteristics that VEPs must have in order to maximize their effectiveness.*

## INTRODUCTION

The Chesapeake Bay is a significant source of economic activity for much of the Mid-Atlantic region, providing food, increasing recreation, and enabling trade for the region, and had an estimated economic value of over \$1.2 trillion dollars in 2004.<sup>2</sup> However, over the last several decades, increasing economic activity within the Bay's watershed has caused degradation of the Bay's waters, plant and animal life, and consequently, impaired local and regional economies in the process. To address these issues, in the year 2000 the states of Maryland, Virginia, Pennsylvania, the District of Columbia, and the federal government created the Chesapeake 2000 program. The program is a voluntary agreement designed to improve the environment within the Bay's watershed, with each state adhering to specific goals and processes to improve the environment and achieving these goals by 2010.<sup>3</sup> The idea behind the program is that the combination of actions taken by the signatories will lead to significant

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<sup>1</sup> The author would like to thank the U.S. Department of Agriculture and the Chesapeake Bay Program for their work in collecting, and also regularly updating, their datasets on the Chesapeake Bay's watershed.

<sup>2</sup> "Chesapeake 2000." Last modified June 28, 2000, accessed November 28, 2013, [http://www.epa.gov/region03/chesapeake/grants/2013Guidance/Attachment1\\_Chesapeake\\_2000\\_Agreement.pdf](http://www.epa.gov/region03/chesapeake/grants/2013Guidance/Attachment1_Chesapeake_2000_Agreement.pdf).

<sup>3</sup> Ibid.

improvements for the Bay as a whole. The states also undertook this program to avoid future pollution abatement requirements by the EPA. This study seeks to evaluate this program and its effect on concentrations of phosphorus and nitrogen in the Bay's water over time.

While most of the Chesapeake 2000 program consists of unquantifiable goals, there are some concrete numbers that provide a viable basis for evaluation. The program attempts to achieve a 40 percent reduction in total nutrients entering the Bay from 1987 levels.<sup>4</sup> This evaluation will break down the nutrient levels into components, including phosphorus and nitrogen, to determine if the program resulted in declining levels for these specific elements. The evaluation will also examine whether these nutrient categories met their 40 percent reduction goals, since elevated levels of phosphorus and nitrogen are key factors in the algal blooms that cause "dead zones" in the Bay during the summer months (Officer et. al. 1984).<sup>5</sup>

This study will also control for trends in population growth and cropland, because they are two major factors influencing the Bay's health and its levels of phosphorus and nitrogen. Population growth leads to increased economic activity, including construction and development of industry, and commercial practices that can contribute to pollution in the region, while agriculture is a main source of fertilizers, which contain high levels of nitrogen and phosphorus to encourage plant growth. A "decoupling" of nitrogen and phosphorus levels from trends in both cropland coverage and population growth could signal that the program is having a positive effect on reducing pollution even when facing increasing potential environmental pressures over time.

## LITERATURE REVIEW

As the environmental movement evolved throughout the 1980s and 1990s, voluntary environmental programs (VEPs) between governments, businesses, and industry became a staple method in these entities' attempts to increase environmental health. Voluntary agreements can provide a number of benefits to their signatories, including flexibility in achieving environmental goals, high involvement among entities that traditionally have been averse to environmental regulation, and increased information-sharing.<sup>6</sup> VEPs can provide valuable incentives to both private firms and government entities alike to help ensure compliance with the agreement, encouraging participation by more firms as the original participants benefit from incentives or recognition.<sup>7</sup> VEPs can also help businesses avoid the threat of additional regulation from governmental entities, and help them increase their company image (and

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4 Ibid.

5 Charles B. Officer et. al., "Chesapeake Bay Anoxia: Origin, Development, and Significance." *Science* 223 (1984): 22-27, accessed November 23, 2013, <http://bioeoes660-f12-bowen.wikispaces.umb.edu/file/view/Officer%20et%20al.%201984.pdf>.

6 Patrick ten Brink, *Voluntary Environmental Agreements: Process, Practice, and Future Use*, London: Greenleaf, (2002), 32-33.

7 Kathleen Segerson and Thomas J. Micheli, "Voluntary Approaches to Environmental Protection: the Role of Legislative Threats," *Fondazione Eni Enrico Mattei (FEEM) Series on Economics, Energy and Environment* 14 (1999): 105-120, accessed November 25, 2013, [http://link.springer.com/chapter/10.1007/978-94-015-9311-3\\_7](http://link.springer.com/chapter/10.1007/978-94-015-9311-3_7).

consequently their market share) by providing evidence of their environmental awareness.<sup>8</sup> Ideally, VEPs also concurrently help governments by reducing the need to create environmental regulations and by avoiding adding “red tape” that is a frequent complaint of industry and subject to legal challenges.<sup>9</sup>

VEPs that have been effective at achieving common environmental goals have also been used to improve water body quality in the past. For example, one such program, the Wetlands Reserve Program (WRP), was instrumental in creating over 33,200 hectares of wetlands in the Lower Mississippi Alluvial Valley.<sup>10</sup> The WRP’s negative economic impact on Louisiana’s economy was minimal, suggesting that the program created improvements to the ecosystem without jeopardizing economic growth in the region.<sup>11</sup> This does not mean, however, that the program was not costly: the estimates for restoring a million acres of wetlands projected that it would cost the government almost \$2 billion.<sup>12</sup> Nevertheless, the example of the WRP shows that, if designed and implemented properly, VEPs can be effective in producing significant environmental benefits while allowing for continued economic growth.

While VEPs have had some success at improving the environmental habits of both private firms and regulatory agencies, a growing body of literature has recently begun to question their effectiveness and examine the limitations of these programs when compared to traditional regulatory practices. One of the biggest criticisms of VEPs results from the fact that they allow some entities to “free ride,” where they obtain the benefits of the program and tout its cumulative results, but they themselves do little to increase their own environmental performance. This results in lower program impacts than are theoretically possible if each firm or governmental structure fully commits to pollution reductions.<sup>13</sup>

Additionally, it is possible that voluntary agreements can be manipulated by governments or firms to give the appearance that those entities are becoming more environmentally friendly, when in fact those organizations are not taking any steps to become more ecologically attentive.<sup>14</sup> Furthermore, VEPs are much more limited in scope than traditional regulation: whether it is at the state or local level, because

8 Dinah A. Koehler, “Voluntary Environmental Programs—A Policy at a Crossroads?” *Policy Studies Journal* 35, no. 4 (2007): 689-722, accessed November 29, 2013, doi: 10.1111/j.1541-0072.2007.00244.x.

9 Thomas P. Lyon and John W. Maxwell, “Self-regulation, taxation and public voluntary environmental agreements,” *Journal of Public Economics* 87, no. 7-8 (2003): 1453-1486, accessed November 20, 2013, doi: 10.1016/S0047-2727(01)00221-3.

10 Sammy L. King, Daniel J. Twedt, and R. Randy Wilson, “The Role of the Wetland Reserve Program in Conservation Efforts in the Mississippi River Alluvial Valley,” *Wildlife Society Bulletin* 34, no. 4 (2010): 918, accessed November 29, 2013, doi: 10.2193/0091-7648(2006)34[914:TROTWR]2.0.CO;2.

11 Williams O. Olatubi and David W. Hughes, “Natural resource and environmental policy trade-offs: a CGE analysis of the regional impact of the Wetland Reserve Program,” *Land Use Policy* 19, no. 3 (2002): 231-241, accessed November 25, 2013, doi: 10.1016/S0264-8377(02)00017-0.

12 Randall Kramer and P. J. Parks, “A Policy Simulation of the Wetlands Reserve Program,” *Journal of Environmental Economics and Management* 28, no. 2 (1995): 223, accessed November 25, 2013, doi: 10.1006/jeeem.1995.1015.

13 Magali Delmas and Arturo Keller, “Free riding in voluntary environmental programs: The case of the U.S. EPA WasteWise program,” *Policy Sciences* 38, no. 2-3 (2005): 91, accessed November 29, 2013, doi: 10.1007/s11077-005-6592-8.

14 Toddi A. Steelman and Jorge Rivera, “Voluntary Environmental Programs in the United States: Whose Interests are Served?” *Organization and Environment* 19, no. 4 (2006): 505, accessed November 25, 2013, doi: 10.1177/1086026606296393.

VEPs are voluntary agreements they cover far fewer entities than traditional regulatory structures can affect, leading to lower levels of pollution abatement or environmental technology adoption.<sup>15</sup>

The most successful VEPs share four consistent characteristics: well-defined goals, sufficient incentives to encourage firms to participate, rules to prevent “free riding,” and a strong threat of regulatory action if firms do not improve;<sup>16</sup> however, the Chesapeake 2000 Program is a mixture of both the strengths and weaknesses of these types of agreements. While it does have some specific goals for certain Bay quality indicators, the program lacks incentives for its continued adherence by the state signatories. The agreement also lacks provisions for “free-riding,” so it is possible that some states may be more lax in enforcing this agreement than others. Furthermore, the goals of this program do not delegate specific assignments to different states so that each state has concrete goals. This may cause issues where states may not implement the plan as well as possible because of a lack of understanding and planning due to ambiguity with the goals themselves. However, because the program was designed to prevent strong regulatory action by the EPA, it is possible that this incentive was enough to force compliance by state governments and produce meaningful economic amelioration for the Bay’s watershed. All of these characteristics are important to remember when evaluating this program, as they may ultimately determine the levels of success achieved by the program during its existence.

## METHOD & MEASURES

### *Data*

The data on both nutrients used for this study, as well as population, came from the Chesapeake Bay Program’s Restoration and Protection Efforts and Bay Health datasets. Data for each indicator were selected from these databases because they provide the most comprehensive data collection of many Chesapeake Bay measurements. Population data before 2000 were extrapolated under the assumption that population changed by the average 1990’s rate of growth in the watershed throughout the decade.

Cropland data was taken from the United States Department of Agriculture’s Farm Census Data. Cropland figures were gathered for each state in the Bay’s watershed for the 1992, 1997, 2002, and 2007 censuses and then multiplied by the percentage of each state that was contained within the Bay’s watershed to get an estimate of the total acres of cropland. The difference between two census tallies was then extrapolated to get the change in acres between census years.

Each continuous variable was also divided into two subsets: a control group and a treatment group. The measurements taken for the nine years preceding the program’s implementation constitute the control group of observations, while the ten years the

<sup>15</sup> Cary Coglianese and Jennifer Nash, “Government Clubs: Theory and Evidence from Voluntary Environmental Programs,” Working Paper 50, Corporate Social Responsibility Initiative, 2008. <http://www.artsrn.ualberta.ca/claypool/courses/art301-2009/301%20PDF%20files/Chicago%20copy.pdf> (accessed November 29, 2013).

<sup>16</sup> Anna Alberini and Kathleen Segerson, “Assessing Voluntary Programs to Improve Environmental Quality,” *Environmental and Resource Economics* 22, no. 1-2 (2002): 157-184, accessed November 29, 2013, doi: 10.1023/A:1015519116167.

program was in effect constitute the treatment group.

Data for the hurricane variable was taken from the National Oceanic and Atmospheric Administration's Past Track Seasonal Archives database. Each year in the study was examined to see if the path of a hurricane or tropical storm passed over the watershed for that year. The variable was then coded to reflect the presence or absence of a tropical storm or hurricane in the region each year.

### *Measures*

**Predictor.** The predictor variable is whether the program existed for each year that measurements were taken for the indicators. The variable was coded as a "1" for each year the program was being implemented, and a "0" otherwise.

**Outcome.** There are two outcome variables for this study. "Phosphorus" is a continuous variable which measures the amount of phosphorus in the Bay's waters in pounds per year. "Nitrogen" is also a continuous variable that measures the amount of nitrogen entering the Bay in pounds per year. Both variables include depositions from point and non-point sources in their totals.

**Control Variables.** Hurricane is a categorical variable. For each year in the study that a hurricane or tropical storm passed over all or part of the watershed, the variable was coded as a "1"; otherwise, the variable was coded as a "0". Cropland is a continuous variable denoting the total acreage of cultivated land within the Chesapeake Bay watershed, and is measured in acres. This variable was included to control for changes in amounts of cultivated land, because agriculture is one of the biggest determinants of nutrient levels in the bay. Population is a continuous variable representing the change in population in the Bay's watershed over time, and is measured in millions of people. Population increases are also typically correlated with increased pollution in the bay area.

### *Hypotheses*

This study expected that the program will have a negative impact on both phosphorus and nitrogen levels and trends in the Chesapeake Bay due to various measures that states took to try to attain the goals of the agreement. This study also expected there to be significant negative differences in average pollutant levels entering the Bay per year between the control and treatment groups due to the presence of the program being implemented.

## ANALYTIC STRATEGY

The method of analysis performed on this dataset was multivariate ordinary least squares estimator (OLS) for two time periods while controlling for population, cropland, and the presence or absence of tropical systems. OLS was performed on the data to examine trends in nutrient reduction before and after the Chesapeake 2000 program's implementation. Variables used in this study were tested for multicollinearity using variance inflation factors (VIFs); the regressions were tested for omitted variables

as well by utilizing the Ramsey RESET test. White’s test was also performed on the regressions to check for the presence of heteroskedasticity.

Both subsets within the dataset were also subjected to t-tests to determine if the difference between each outcome variable was different from 0 in order to analyze the general effects of the program on nutrient levels. The trends were then compared against each other to determine whether there was a difference in trend patterns for both nutrients while the program was being implemented.

## RESULTS

### *Descriptive Statistics*

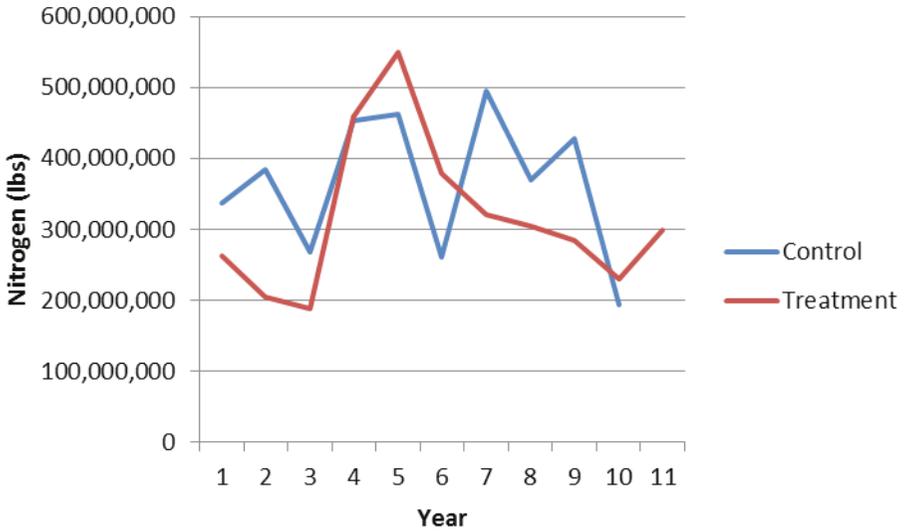
The final analysis for nitrogen showed a mean of 340 million pounds per year with a range of 361 million pounds per year, while the final results for phosphorus revealed a mean of 20 million pounds per year, and a range of 40 million pounds per year. The average amount of nitrogen entering the Bay during the program’s implementation was 13.35 percent lower than the average of the decade before, and the average amount of phosphorus declined by 8.54 percent while the program as in place. One third of all the years studied contained the path of a hurricane or tropical storm passing over the Bay’s watershed. Over the twenty year period of the study, cropland decreased by 26.5 percent (1.54 million acres), while population increased by 22 percent (3.13 million people).

### DESCRIPTIVE STATISTICS – CONTINUOUS VARIABLES

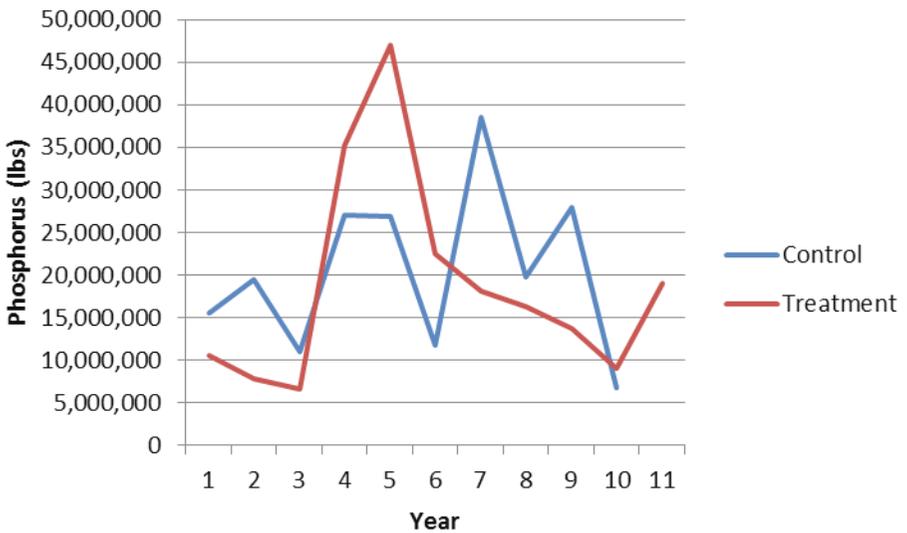
<i>VARIABLES</i>	<i>min</i>	<i>max</i>	<i>mean</i>	<i>std. dev</i>
Nitrogen (lbs)	1.88e+08	5.49e+08	3.40e+08	1.05e+08
Phosphorus( lbs)	6660000	4.70e+07	1.96e+07	1.10e+07
Population (millions)	14.23336	17.36047	15.74961	.947241
Cropland( acres)	5803589	7341968	6919728	501755.4
Observations	21			

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*Nitrogen (pounds/year) Entering the Bay: 1990-1999 and 2000-2010*



*Phosphorus (pounds/year) Entering the Bay: 1990-1999 and 2000-2010*



*T-test Results*

T-test results do not support the hypothesis that average pollutant loads for nitrogen and phosphorus are lower while the program was implemented relative to the control. While there was a negative difference in averages between the control and treatment groups, the result was not significant at any level for either pollutant. This means that average levels of nitrates and phosphates entering the Bay during the program’s duration were not significantly different than during the control timeframe.

T-TEST

<i>VARIABLES</i>	<i>difference</i>
Nitrogen (lbs)	48745454.5 (1.07)
Phosphorus (lbs)	1750818.2 (0.36)
Observations	21
t statistics in parenthesis	
* p<0.05, ** p<0.01, *** p<0.001	

*Regression Results*

OLS regression results also do not support the hypothesis that the program produced significant reductions in either phosphorus or nitrogen. However, when the regressions were re-run while controlling for hurricanes and tropical storms, OLS revealed that the program was significant at the 5 percent level in causing reductions of both nitrogen and phosphorus. In this case, the application of the program resulted in a decrease of over 40 million tons of nitrogen, and one million tons of phosphorus, holding all other variables constant in the model. This was true regardless of whether the regression was run with either cropland or population as a control variable.

REGRESSION RESULTS (WITH HURRICANES)

VARIABLES	nitrogen	phosphorus
cropland	303.8 (190.3)	36.95 (21.88)
program	2.946e+08 (1.606e+08)	3.532e+07 (1.846e+07)
Constant	-1.889e+09 (1.385e+09)	-2.499e+08 (1.593e+08)
Observations	7	7
R-squared	0.459	0.481

*Standard errors in parentheses*

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

REGRESSION RESULTS (WITHOUT HURRICANES)

VARIABLES	nitrogen	phosphorus
cropland	-44.23 (48.98)	-5.458 (4.259)
program	-1.497e+08** (5.099e+07)	-1.196e+07** (4.434e+06)
Constant	7.079e+08* (3.585e+08)	6.105e+07* (3.117e+07)
Observations	14	14
R-squared	0.498	0.417

*Standard errors in parentheses*

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

DISCUSSION

The goal of this study was to determine whether the Chesapeake 2000 Program, a voluntary environmental program (VEP), would produce significant differences in levels of phosphorus and nitrogen in the Chesapeake Bay during its duration of existence. VEPs like the Chesapeake 2000 Program are becoming prevalent methods for reducing environmental pollution, so it is imperative that they are examined to make sure policymakers maximize their effectiveness when designing them. This study hypothesized that the program had a significant effect towards reducing amounts of both pollutants due to a strong threat of federal regulation and clearly defined goals, but the data did not support this hypothesis unless hurricanes were controlled for in the regression. However, these results do indirectly support existing literature on the topic because they lend support to the consensus that these programs need clear, defined goals, incentives for participants to work hard at implementing the program’s goals, sanctions to prevent “free riding,” and strong threat of regulatory action to enforce compliance.

The four characteristics of successful VEPs mentioned earlier in this study are essential to allow programs like Chesapeake 2000 to operate effectively. The program possessed two of those four traits, as it included specific goals and also carried with it the threat of federal action to force states to comply if they did not reach their stated goals. However, one of its biggest shortcomings was a lack of provisions to prevent free-riding. Three different states and one district participating in the program means four different governments that can find ways to circumvent the agreement without facing recriminations. This may have led to lower levels of effectiveness than would have been possible if incentives to reduce free-riding were included in the program. The lack of positive incentives included in the agreement may have also blunted the program’s potential, further contributing to this study’s incorrect hypotheses.

One additional factor that may have contributed to this study’s incorrect hypothesis is the size of the agreement that was implemented. The Chesapeake 2000 program involved the federal government, three states, and a district. The scale of this agreement may have made it difficult for the states to coordinate their efforts to improve the

Bay effectively. It is also possible that the program was too generalized and had too many goals to have much effect on the Bay's health. Voluntary programs that involve multiple states, like the Regional Greenhouse Gas Initiative, have had more success because they are focused on one specific goal. The Chesapeake 2000 program may have had better results if it had fewer or more concentrated goals, instead of its wide scope of objectives.

It is hard to regulate the environment effectively. The presence of outside factors can render the most well thought-out regulatory designs impotent from year to year. For example, in the third year of the Chesapeake 2000 Program, the Bay received 194 million tons of nitrogen and phosphorus, but the following year, Hurricane Isabel's impact on the Bay's watershed resulted in 494 million tons of these pollutants entering the Bay, a 150 percent increase from the previous year. These events can effectively mask any progress the Program may make on the Bay's health otherwise. Because the program showed a significant decline in both pollutants studied when these outlying events were removed, it is possible that the program ended up providing some benefit to the Bay's overall health. But because these factors will continue to influence the Bay's watershed in the future, it is difficult for environmental programs like this one to respond to them effectively, or for their results to be validated as beneficial.

#### LIMITATIONS

One of the most difficult and limiting aspects of examining this program is that many of the variables that have readily available data are all highly correlated with each other. The variables "cropland" and "population" were over 90 percent correlated when tested for multicollinearity, and when another variable, "forests," was added, it also correlated very highly with existing variables (over 95 percent correlation). The presence of severe multicollinearity between multiple variables meant that several of them had to be dropped from the regression, leading to a less comprehensive analysis than this study originally intended. The fact that multicollinearity exists between so many variables is troubling: it suggests that it could be difficult to add more variables to the regression, if so many of the major ones closely relate to each other. This also lowers the internal validity of the study: as one variable is dropped, the results of the regression shift dramatically, decreasing the consistency of the model. This also may increase the potential for omitted variable bias in the equation itself, necessitating further testing. Furthermore, the small N in the data sample may have skewed the results as well.

While testing of the regression equations suggests that omitted variable bias was avoided by the study in this case, there are still several factors that would have made for a more complete study if data on them were more readily available. One way to measure state commitment to the program would be to look at funding for the Bay during the program's implementation. Overall funding may help to explain some of the differences between pollutant levels, as higher funding could translate to better agricultural practices and more buffers in place to reduce runoff into the Bay. Looking at industrial statistics might be a good basis for a further study, since the program may have had positive impacts on industry pollution controls or controls for

other point sources within the Bay watershed, even if those statistics are less readily available. Furthermore, population could be examined further in a future study. Past population increases in the Bay's watershed were concentrated in the suburbs, which led to increased fertilizer from lawns running off into the Bay. However, the majority of recent population growth may have been concentrated in urban cores due to the Millennial generation moving back into city centers, leading to less suburban expansion and therefore, less fertilizer runoff compared to population.

#### IMPLICATIONS FOR POLICY & PRACTICE

The results of this study serve to highlight and reinforce the need for VEPs to include all four principles that previous research has highlighted as characteristics of effective and successful voluntary programs. When designing VEPs, policymakers must make sure to include clearly defined goals, sanctions against free-riding, incentives to encourage participation, and a strong threat of regulatory action should firms or entities not comply. The Chesapeake 2000 program only had two of the four principles: there were no incentives to improve state participation and no provisions to prevent "free riding". Policymakers should also examine the size and scope of the problem in order to determine whether a VEP is the best solution: problems with large physical sizes or wide scopes will be more difficult to control and manage effectively. While VEPs may produce significant results for targeted issues, when these agreements are applied to issues that are state-wide or involve multiple states, they have greater potential to fail. Instead, legislators should continue to view VEPs as a part of an "all-of-the-above" strategy, complementing traditional regulatory approaches or various market-based solutions to achieve environmental results. Currently, the Chesapeake 2000 Program is discontinued because it failed to meet its goals, and the Bay Watershed is now under federal regulation since President Obama's Executive Order went into effect in 2010. Lawmakers should learn from the shortcomings of this program so that any future endeavors using these types of programs can be more effective in achieving environmental goals without the potential economic burdens of traditional regulation.

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