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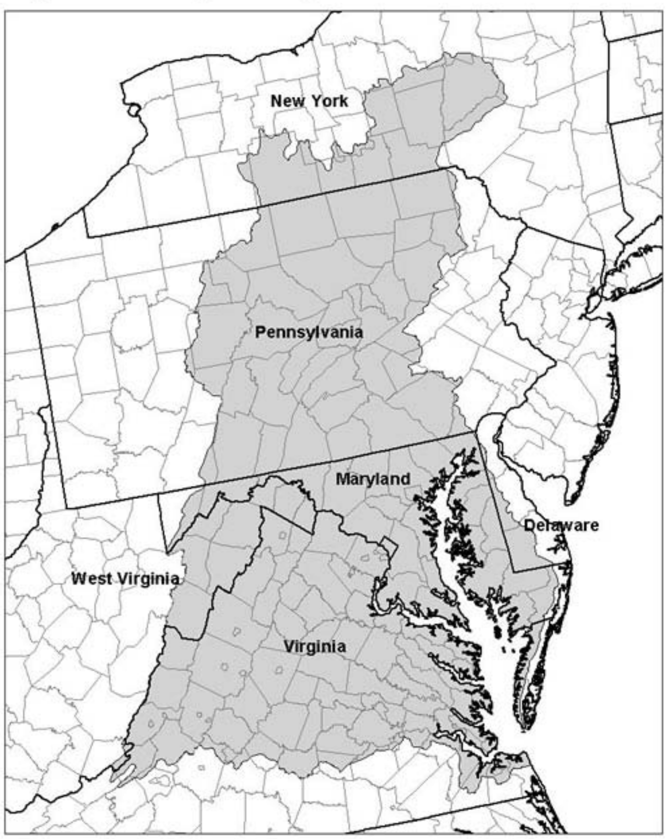
# THEME OVERVIEW: INNOVATING POLICY FOR CHESAPEAKE BAY RESTORATION

**Marc Ribaudo and James Shortle**
JEL Classification: Q58
Keywords: Nonpoint Source Pollution, Total Maximum Daily Load (TMDL), Best Management Practice, Conservation Program, Policy Instruments

The Chesapeake Bay is North America's largest and most biologically diverse estuary. It has provided a rich bounty of crabs, shellfish, and fish, and high quality recreational opportunities. However, the Bay living systems have been increasingly stressed over time by the pressures of growing populations—there are over 20 million people in the 166,534 $km^2$ mile watershed—industrial pollution, atmospheric deposition of air pollutants, and conversion of forests to farms—especially animal intensive farming—and to urban development. Significant reductions in polluting discharges from sewage treatment plants, factories, and other point sources of pollution have been achieved in the Bay watershed since the 1970s. But these reductions have not been enough to meet established water quality goals because point sources are only part of the problem. Nonpoint sources, especially agricultural ones, are a major remaining source of the nutrients and sediments degrading the Bay.

**Figure 1: Chesapeake Bay Watershed**



The history of efforts to restore the ecosystem of the Chesapeake Bay is emblematic of the failure to solve the agricultural nonpoint source (NPS) problem. The Bay has been a focal point of federal and state initiatives to reduce nutrient and sediment pollution from agriculture and other sources for more than thirty years. Beginning in 1983, there have been several agreements between the U.S. Environmental Protection Agency (EPA), the Governors of Maryland, Pennsylvania, Virginia, West Virginia, Delaware, and New York, and the Mayor of the District of Columbia that established the Chesapeake Bay Program, set nutrient and sediment reduction goals, and developed strategies for nutrient and sediment reduction. U.S. Department of Agriculture (USDA) conservation programs have made large public investments in improving the management of agricultural resources and reducing agriculture's negative impact on environmental quality. Additional investments have come from EPA programs—208 and 319 funds—and from the watershed states. Yet, the problems remain—largely due to limited success in implementing policies that effectively reduce environmental stress from agricultural nonpoint sources of pollution. The fact that much of the watershed lies in areas that do not benefit directly from a cleaner Bay may have played a role in this.

The limited progress in achieving water quality goals has led the EPA to establish a Total Maximum Daily Load (TMDL) for the Bay. The TMDL, the largest ever developed by the EPA, calls for reductions in nitrogen (25%), phosphorus (24%) and sediment (20%) in the Bay watershed. It requires states in the watershed to develop Watershed Implementation Plans (WIPs) for achieving target reductions from agriculture and other sources. Although there are some exceptions, the WIPs largely rely on policy approaches traditionally used in federal and state programs.

The articles in this theme critically explore the suite of federal and state polices needed to reduce water pollution in the Chesapeake Bay. They examine shortcomings of existing policy approaches and highlight opportunities for correcting those deficiencies from economic, political, legal, ecological, and policy perspectives. The article by Hershner provides some perspective on the challenges and uncertainties of improving the quality of such a large and complex ecosystem, and how these might influence policy choices. Ribaudo, Shortle, Blandford, and Horan review the shortcomings of current policy approaches to address agricultural NPS pollution and suggest some "tweaks" that might provide more effective pollution reductions. The use of regulation as a policy tool is further explored by Perez. The article reviews the use of regulation to address the pfiesteria outbreak of the 1990's, and the lessons learned that could be applied to the current policy. Another policy approach, payment for ecosystem services (PES), is evaluated by Shabman, Rose, and Stephenson. That article argues that the Bay may not be suitable for a traditional PES approach, and suggests an alternative based on PES principals that may have a better chance for success. An area that has not been much explored in the literature is the role politics plays in establishing goals and selecting policy instruments. Kwasnica tackles this subject in a paper that examines how the political process in a representative democracy and federal system of governance might impact the allocation of load reductions and influence the success of the Bay policy.

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# THE CERTAINTY OF CONFRONTING UNCERTAINTY IN THE CHESAPEAKE BAY RESTORATION EFFORT

**Carlton Hershner**
JEL Classifications: Q00, Q01, Q20, Q28
Keywords: Environmental Restoration, TMDL, Chesapeake Bay, Adaptive Management, Uncertainty

The Chesapeake Bay is a very large complex system that no longer has the capacity to provide all of the beneficial human services it once did. Restoring some of that capacity is a consensus goal for the millions of people who live in the watershed and impact its condition. The challenges of improving the condition of such a large ecosystem lie not only in assembling the necessary resources, but also in knowing what must be done and how best to do it. These questions are at the very limits of our current knowledge and so there is inherent uncertainty in all the answers. The amount of uncertainty varies from very little—identification of the system's problem and the causes, to moderate—determination of the exact amounts of excess pollutant loads from all parts of the watershed, to significant—forecasting the performance of best management practices. Since the system will continue to degrade if nothing is done, inaction is not an option. Moving forward requires a willingness to act with less than perfect knowledge, constantly striving to reduce the uncertainty by learning and adapting as we go.

What follows is a brief review of some of the principal questions decision-makers currently confront in efforts to restore water quality conditions in the Chesapeake Bay. The answers to these questions vary significantly from "nearly certain" to "best available estimate." Understanding this circumstance is central to both designing the strategy and setting expectations.

### What Is the Problem?

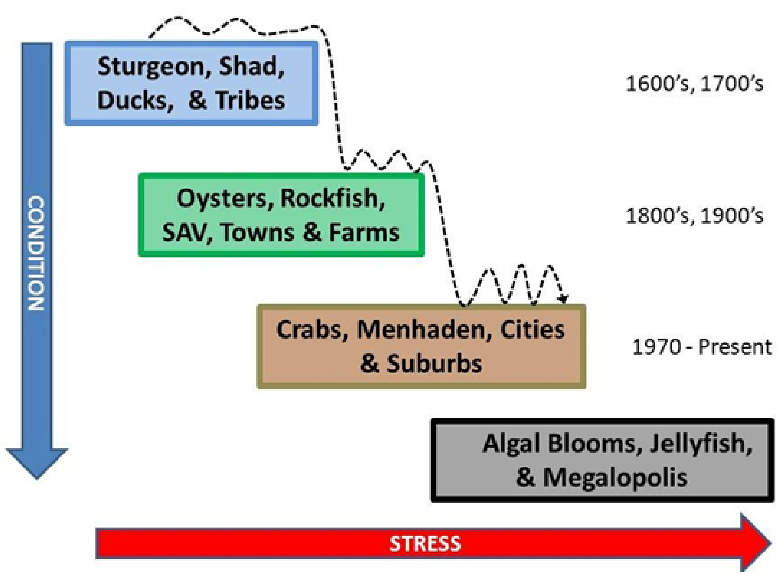
Scientists have been studying the Chesapeake Bay for decades. As the largest estuary in North America, it is both very interesting and very important. Since colonists first arrived the population living around the Bay and its tributaries have relied on it for food, transportation, recreation, and waste removal. It plays a large part in the economy of the region and its productivity and condition are of constant concern. Decreases in fisheries productivity were some of the first signs that the system was changing. Declines in finfish and shellfish harvests, particularly oysters, and changes in waterfowl populations were noted by watermen, sportsmen, and scientists as early as the end of the 19$^{th}$ century. A dramatic decline in submerged aquatic grasses in the early 1970's was one of the factors that spurred increased interest in understanding what was happening to the system.

Current thinking among scientists describes dramatic changes in ecosystems, like the Chesapeake Bay, as "regime shifts". It is believed that, through time, ecosystems organize themselves in response to the pattern and level of stresses they experience. For example, the frequency and severity of storms will determine the opportunity for mature forests to become established or for marshes to persist along shorelines. Similarly, the amount of harvest pressure applied to a fish community will determine how many, what kind, and even what size of fish can survive in the system.

At the scale of entire systems, the ecological regime concept implies that as stress levels increase, the natural capacity of the system to resist change and/or recover from severe events is slowly overcome. There comes a point as stress levels increase, when some components of the system are no longer able to persist. When enough critical components have been affected, the system effectively reorganizes itself with a revised cast of organisms, more suited to prevalent stresses. This is referred to as a regime shift.

When a regime shift occurs, the system's composition and energy pathways are altered, and the reorganized system typically has a reduced capacity to provide traditional services to human users. In the case of the Chesapeake Bay, declining condition resulted in losses in the system's capacity to provide suitable habitat for some species of birds and fish, support some commercial and recreational fisheries, buffer storm impacts, and provide recreational and aesthetic opportunities for a variety of users as seen in Figure 1.

**Figure 1:Chesapeake Bay regime shifts**




**The Chesapeake Bay ecosystem is hypothesized to undergo changes in structure andfunction as stresses increase. The changes are called regime shifts and represent a reorganization of the system as major components are lost. Recovery to a previous regime with higher values for humans can require reduction in stress beyond the point at which the system was first degraded.**

The problem in the Chesapeake Bay is that stresses have increased sufficiently to cause significant changes in the nature of the system. While it remains an incredibly productive system, the production no longer occurs in forms we tend to prefer. Instead of ending up in oysters and large fish, most of the production is now found in plankton, algae, and bacteria. Preventing further unwelcome change in the system requires that we reduce the stressors that are causing its degradation.

Therefore the answer to the question regarding what is the problem may be found in the system stress level leading to a condition that is not optimal or even desirable. This is certain.

**What Is Causing the Problem?**

Scientists recognized that the primary stresses on the Bay ecosystem are generated by the millions of people who live in and use the watershed. While overharvesting of fish stocks, shellfish diseases, and rapid coastal development all played roles in the system's decline, scientists concluded that decreased water quality was a primary factor in many of the unwelcome changes. Too many nutrients—nitrogen and phosphorus compounds—and too much sediment have found their way into the system as a result of development, farming, forestry, and industrial practices of the past several centuries.

This understanding was derived from a combination of direct observation and experimentation. For both nutrients and sediments, monitoring stations at the fall lines of the principal Bay tributaries provide direct measurements of the modern loads coming from the watershed. Scientists also used well established methods to date the sediments already in the Bay and its tributaries. This allowed them to calculate the historic loads, documenting the impacts of land clearing and land disturbing activities since the time the first colonists arrived. Experimental evidence provided the primary explanation of the impact nutrients were having on the system. In controlled conditions, scientists conclusively demonstrated that the small floating plants, which are naturally found in estuarine systems like Chesapeake Bay, respond to increased nutrients just like any other plant – they grow and reproduce faster. In fact, it became clear that at the levels of nutrients found in the Bay, these plants frequently grew far faster than they could be eaten by the animals that feed on them. The results are the phytoplankton and algal blooms that often color the water and keep light from reaching the bottom.

Through both monitoring and experimentation, the impact of large phytoplankton blooms was discovered to include the depletion of oxygen in the deep waters of the Bay. Phytoplankton that is not successfully grazed by zooplankton, dies and sinks to the bottom. There it is decomposed by bacteria, which use up all the oxygen available in the surrounding water in the process. The result is hypoxia—very low oxygen levels—or anoxia—no oxygen, making the area unsuitable for other higher life forms such as fish, clams and worms. The end result is a “dead zone”, an area in which few if any organisms can survive. And this all starts with excess nutrients added to the system.

The answer to the question “what is causing the problem” is therefore also certain. Through direct observation and extensive experimentation, excess sediment and nutrients have been unequivocally identified as primary factors in the degradation of water quality conditions in the Bay and its tributaries.

**How Do We Fix It?**

The answer to this question would seem patently obvious. If the problem is excess sediments and nutrients, the solution is to reduce the loads. However, this leads to the questions of 1) how much nutrient loads must be reduced and 2) how to accomplish this.

The magnitude of required nutrient load reduction is estimated based on two primary types of information. The first is the many years of monitoring that have been undertaken to understand how the Bay responds to nutrient and sediment loads. The second type of information is the controlled experiments that have been undertaken in laboratories to investigate the response of individual organisms or small communities to different pollutant loads. These two lines of information are combined to predict the response of the Bay system to large scale changes in the loads coming from the watershed. Managers, scientists, and stakeholders identify the conditions we would prefer to have in the Bay and that is then matched to the nutrient and sediment loads that would allow those conditions to persist.

Clearly this is not a precise undertaking. The available evidence strongly supports the presumption that managing pollutant loads to the identified levels will result in restoration of the desired conditions. But at the bottom line, this is forecasting behavior of a very complex and organic system. Relatively constant behavior by the human components of the system is modified by variable weather conditions from year to year and the result is a fluctuating response in Bay conditions. Averaged over many years however, we are confident we can see the impact of management changes—reduced pollutant loads lead to improved ecosystem conditions.

So, we know generally how to fix the problem. There is a great deal of certainty that the system will respond positively to the management efforts. The uncertainty that remains in knowing how to fix the system arises from the fact that pollutant loads are not the only factor determining the condition and/or ecological regime for the Bay. Other factors, such as fishing pressure, are also important and must be managed effectively along with the efforts to restore water quality conditions. Still other factors, like climate change, will potentially affect our management efforts in a variety of ways that will only be determined through time.

### How Do We Decide Who Does What?

The biggest challenge in restoring the Bay arises from the fact that there is such a large area in which activities generate impacts to the system. The 64,000 square mile watershed for the Bay covers areas that are relatively remote from the Bay shorelines. And yet it is the cumulative actions across this entire land surface that created the loads that have reduced Bay conditions. There is no single type of activity, nor any small portion of the watershed that can be modified sufficiently to restore the target conditions. Success requires targeting management efforts to the sources of the pollutant loads throughout the watershed.

The complication arises from knowing exactly where the loads are generated and how they are transmitted to the Bay. This is where the first bits of significant uncertainty begin to arise.

We think of load sources in the Bay system in two broad categories: point sources and nonpoint sources. Our knowledge about how much of the pollutant loads are derived from each of these sources is not perfect.

Point sources are discrete, easily identified discharges to the Bay system. They include things like municipal and industrial wastewater facilities, sewer overflows, confined animal feeding operations, and stormwater system discharges. Point sources are largely regulated, and the permits for these discharges typically require some monitoring of the delivered loads. As a result, point sources, at least those large enough to require permits, are well documented and there is relatively little uncertainty associated with their contribution to the total loads entering the Bay.

Nonpoint sources are basically everything else. Pollution that finds its way into the Bay system through runoff, seepage, precipitation, air deposition, shoreline erosion, or tidal influence are all considered to arise from nonpoint sources. Some of our information about the loads generated by nonpoint sources comes from monitoring and some comes from a mix of inductive and deductive reasoning, most of it facilitated by rather sophisticated models.

The process used to generate landuse load estimates for the entire Bay watershed allow us to have a high degree of confidence in the average performance of farms, developments, forests, and so on. The uncertainty that is inherent in these estimates only becomes important as the size of the area being evaluated shrinks. The smaller the watershed modeled with the general load estimates, the higher the uncertainty that the modeling is accurate.

The model used by the Bay Program is an enormously complex, state-of-the-art tool. It has been used to estimate nutrient and sediment loads generated in all parts of the Bay watershed, providing a rational basis for planning restoration efforts. But, it is just a model, and according to the oft repeated phrase generally attributed to George Box—“all models are wrong, some are useful.”

The Bay program model has been very useful. It has supported the analyses that established load reduction targets for the restoration effort. It is now being used to determine where reductions must occur and to assess the consequences of various management strategies. While the model has been carefully and purposefully developed to support these activities, everyone recognizes that these last tasks are at the limits of its abilities to provide spatial resolution of responses. It is not perfect because it was designed to simulate the performance of the entire system, not all the individual parts. As a consequence, it is not being treated as the definitive answer for design of restoration strategies. It is, however, being used to establish the ground rules for the current iteration of the restoration effort.

### How Sure Are We It Will Work?

As noted in preceding sections, there are multiple sources of uncertainty in the effort to restore the Bay. All the activities that will be necessary to maintain and improve conditions in the system are not known, and to some degree cannot be known at this time. Things we do not fully understand at present, like climate change, will undoubtedly affect our ongoing efforts to manage the system. These factors will require adaptation as our knowledge increases. At present, however, we are confident that we have identified a primary factor degrading the system’s condition—water quality. We are quite certain about this, and we are certain about what needs to be done to manage that factor.

Changing long–standing land use practices to mitigate the deleterious effects they generate will not be easy. No one seriously proposes cessation of farming and no one expects a decrease in human populations in the watershed. So reducing pollutant loads requires incorporation of best management practices that allow uses to continue while directly addressing the potential negative consequences.

There are a lot of best management practices available for implementation. All of them have been demonstrated to have the capacity to reduce one or more of the pollutant loads necessary for the restoration effort. They vary widely, however, in their efficacy and capacity to generate long-term benefits. This is the predominant source of uncertainty in restoration planning.

**Figure 2**

**Key questions and answers for restoration of the Chesapeake Bay.**

1. What is the problem? Degraded habitat conditions
2. What is causing the problem? Too many nutrients and sediments
3. How do we fix it? Reduce pollutant loads
4. How do we decide who does what? Use the model
5. How sure are we that the effort will succeed? Certain the effects will be positive. Less certain about precisely achieving the goal
6. What are the options? Monitor and learn–adaptive implementation

What this means for the restoration effort is that we do not know exactly how many, or which, best management practices it will ultimately take to achieve the goal. For some, this is a dispiriting reality. The absence of certainty in the outcome is seen as an argument against committing the enormous resources necessary to undertake current plans. Two things are overlooked from this perspective. First, doing nothing will not improve the system, but rather permit further unchecked degradation. Increasing human populations simply increase the potential loads of nutrients and sediments to the system, and so merely maintaining the status quo requires ever increasing efforts at mitigation. Second, while knowledge of the precise end point for achieving restoration is elusive, every reduction in pollutant loads reduces stress on the system, and thus decreases the likelihood of an unwanted regime shift to an even less desirable state.

**What are the options?**

In the face of the uncertainties detailed above, the development of strategy is challenging, but not daunting. There are at least five possible options:

1. Do nothing
2. Implement the easy actions—voluntary actions and incentives
3. Change expectations—shift the end point towards current standards
4. Try the hard things—mandatory actions and retrofitting existing development
5. Commit to learn while doing—adaptive management

The first option has long ago been discarded as unacceptable.

The second option was effectively the strategy for the past three decades in Bay management. Voluntary efforts and incentive based strategies failed to achieve the goals of the Bay program partners. This was most distressingly clear in the case of water quality for the Bay. Having set the criteria for water quality necessary to support the designated uses of the Bay and its tributaries, the program partners were forced to admit those criteria could not be met and list the waters as impaired.

The third option, to change expectations, is technically still a possibility. However, conditions are currently undesirable, failing to support designated uses of the system. The Clean Water Act, which motivates the ongoing water quality improvement efforts, prohibits changes in designated uses before it is clearly demonstrated that the criteria for those uses cannot be attained. In other words, restoration must be seriously attempted and fail before a change can be considered.

So the Bay partnership finds itself working on option four–try the hard things. These include practices like comprehensive management of storm water, capping nutrient loads from all sources, and requiring limit-of-technology treatment of waste water. The strategies currently being developed and implemented are difficult and expensive, and they confront multiple sources of uncertainty. With few exceptions, the uncertainties are unavoidable and cannot be addressed without taking the actions planned and observing the outcomes.

The Bay program partnership and all the stakeholders in the system are left with a need to act at a large scale, while there is significant uncertainty regarding efficacy of all the possible activities.

A solution for the seeming conundrum is a more phased implementation that allows learning to occur. Sometimes referred to as adaptive implementation, this is a means of reducing the investment risk in restoration efforts, without backing off from the commitment. Instead of wholesale implementation of best management practices that may or may not prove economical, targeted implementation is undertaken, allowing discovery of efficacy and more strategic application of limited public resources.

The trade–off in acceptance of an adaptive implementation approach is lengthening of the restoration time line. Discovery of the most effective and economically efficient means of restoring the Bay will require some time. Implementation can be immediate for those actions that enjoy relatively high surety of effectiveness. But for other actions, admitting the knowledge base is limited and the risk for investment is high, could be the rationale for a more strategic approach to implementation.

**Concluding Comments**

The Bay program partnership has embarked on a difficult but essential task of reducing the stress on a highly valuable natural system. The certainty of success in restoring the system to a more desirable state is not absolute. The strategy being implemented is founded on extensive and well-vetted knowledge. But the sheer size and complexity of the system prevent precise, spatially explicit understanding of behavior and potential response to management efforts. This factor, combined with the imprecise knowledge of the efficacy of many of the practices that will be used to effect restoration, limits ability to forecast outcomes. Despite these limitations, there is little doubt about the type of actions that must be taken, nor the scope of those efforts. The challenge for program managers is how to minimize the impact of inherent uncertainty on the progress and achievements of the restoration effort. Adaptive implementation of the management practices with the greatest attendant uncertainty is suggested as a practical alternative to blanket, hopeful implementation.

**For More Information**

Bay TMDL development and implementation. Available online: http://www.epa.gov/chesapeakebaytmdl/

Chesapeake Bay Program. Available models online:http://www.chesapeakebay.net/modeling

Freedman, P., Reckow, K., Shabman, L., Benaman, J.,Schwer, R., and Stiles, T. (2008). A new approach to adaptive implementation in the TMDL program. *Water Practice* (1):1-9

Simpson, T., and Weammert, S. (2009). Developing nitrogen, phosphorus and sediment reduction efficiencies for tributary strategy practices. BMP assessment: Final Report. Available online: http://archive.chesapeakebay.net/pubs/bmp/BMP_ASSESSMENT_FINAL_REPORT.pdf

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# Improving the Efficiency and Effectiveness of Agri-environmental Policies for the Chesapeake Bay

**Marc O. Ribaudo, James S. Shortle, David Blandford, and Richard D. Horan**
JEL Classifications: Q25, Q58
Keywords: Water Quality, Nonpoint Source Pollution, Policy Instrument, Chesapeake Bay

The Chesapeake Bay is North America's largest and most biologically diverse estuary. Its watershed is home to more than 17 million people. For over 200 years it provided a rich bounty of crabs, shellfish, and fish, and high quality recreational opportunities. However, as the region's population grew and land was converted from forests to farms and to urban development, the quality of the Bay's waters declined, along with its living resources. Significant reductions in polluting discharges from sewage treatment plants, factories, and other point sources of pollution have been achieved in the Bay watershed since the 1970s. But these reductions have not been enough to meet established water quality goals because point sources are only part of the problem. Nonpoint sources, especially agricultural nonpoint sources, are a major source of the nutrients and sediments degrading the Bay.

The history of efforts to restore the ecosystem of the Chesapeake Bay is emblematic of the failure to solve the agricultural nonpoint source (NPS) problem. The Bay has been a focal point of federal and state initiatives to reduce nutrient pollution from agriculture and other sources. Beginning in 1983, there have been several agreements between the U.S. Environmental Protection Agency (EPA), the Governors of Maryland, Pennsylvania, Virginia, West Virginia, Delaware, and New York, and the Mayor of the District of Columbia that established the Chesapeake Bay Program, set nutrient reduction goals, and developed strategies for nutrient reduction. U.S. Department of Agriculture (USDA) conservation programs have made large public investments in improving the management of agricultural resources and reducing agriculture's negative impact on environmental quality. Additional investments have come from EPA programs, for example the Sec. 208 and 319 funds, and from the watershed states. Yet, the problems remain—largely due to limited success in implementing policies that effectively reduce environmental stress from agricultural nonpoint sources of pollution.

The limited progress has led the EPA to establish a Total Maximum Daily Load (TMDL) for the Bay. The TMDL calls for reductions in nitrogen (25%), phosphorus (24%) and sediment (20%) in the Bay watershed. The states were required to develop Watershed Implementation Plans (WIPs) for achieving load reductions from agriculture and other sources. Although there are some exceptions, the WIPs largely call for ramping up traditional policy approaches rather than for innovations to improve the effectiveness and efficiency of the mosaic of federal and state programs. The core elements of the traditional approaches are voluntary adoption of pollution control practices with financial support from federal, and to a lesser degree, state cost-sharing. We believe innovations are imperative for achieving water quality improvements and to do so in ways that are compatible with other societal goals. We present a menu of options for federal and state programs.

### What Is the Problem?

Two basic issues must be addressed if water quality goals are to be achieved. First, the regional nutrient budget is out of balance: more nutrients, primarily in the form of animal feed, are being brought into the watershed than can be assimilated, in the form of manure, by the crops grown. Second, not enough farmers are using the most effective—best—nutrient management practices. The persistence of these problems is not entirely due to a lack of resources. In the Bay, as elsewhere in the United States, water quality protection in agriculture has largely been pursued through voluntary strategies, supported by government financial and technical assistance. Only recently have large animal intensive enterprises been subjected to National Pollutant Discharge Elimination System (NPDES) permit requirements, thereby applying to only a small part of the population of farms. States in the Bay region have had nutrient planning requirements, but historically these have represented a very light form of regulation, with little monitoring and enforcement (USEPA, USDA, 2006).

Progress will require the implementation of programs that lead to increased effort on a much larger number of farms. But given the multiplicity of societal interests related to agriculture and the environment, new initiatives must be more effective than the old. An important goal is the preservation of a vibrant agriculture in the region. This is an established policy goal of the states in the Bay watershed and an expressed priority in the Obama Executive Order on the Bay (White House). It implies the need for instruments that minimize any economic harm to agriculture. Providing farmers with financial assistance for pollution control is consistent with the goal, but the capacity to follow this strategy is likely to become increasingly constrained in the near to medium term due to tight federal and state budgets. Consequently, it is essential that the future mix of policy instruments emphasize cost-effectiveness in pollution abatement; efficiency in the use of public resources for monitoring and enforcement; and, to the extent that these remain mainstays in agricultural nonpoint programs, efficient technical and financial assistance.

There are several characteristics that are conducive to cost-effective pollution abatement. An instrument should have low transactions costs, be durable but flexible, lead those who can reduce pollution at the lowest unit cost to abate the most, and facilitate innovation. Environmental quality in agriculture presents a difficult management problem because of spatial heterogeneity and temporal variability in production conditions relevant to compliance costs and environmental impact. Pollution from farms is highly variable, unpredictable, and for all practical purposes, unobservable. Technological and management innovations in agriculture are rapid and adaptation is essential for economic success, so a policy should not place unnecessary constraints on farmers' actions.

The USDA administers a number of programs to help farmers reduce polluted run-off from farms. The largest is the Environmental Quality Incentives Program (EQIP). EQIP provides financial and technical assistance to farmers for the adoption of specific management practices that protect water resources. Annual funding nationally is currently about $1.2 billion. From 1997 through to 2002, 37% of EQIP funds were spent on water quality and water conservation-related practices; another 28% were spent on managing livestock manure, which is a major source of water pollution (USDA, ERS, 2006).

For a voluntary program to be efficient, it must enroll farmers who can provide abatement at least cost. Current USDA cost-share programs are not designed to do this. Whether a farmer participates and what practices are adopted are the result of a private decision calculus based on perceived private benefits. Since a practice-based cost-share does not take into account the level of pollution abatement provided, private benefits may have a low correlation with downstream water quality outcomes. The consequence is that the use of measures for improving water quality is limited to farmers and practices for which the combination of private benefits and incentive payments is sufficiently large enough to make adoption economically rational. It is improbable that the set of farmers and practices will be optimal for achieving water quality gains at least cost. Indeed, if farms with low pollution control costs or high water quality impacts are not in the set of adopters, the pattern of adoption limits water quality gains and increases the costs of those actually realized. The status-quo approach also requires continuing public and political willingness to foot the bill, which currently appears to be in doubt.

A factor that strains conservation program budgets and diminishes the return on public investment in pollution control is the distortionary effect of nonenvironmental agricultural policies. There is ample evidence that price supports, input subsidies, crop insurance, and other agricultural policies influence the nature, size and spatial distribution of agricultural externalities through effects on the scale and location of input usage and production structure. The best known recent example is the current policy to promote ethanol production, most of which is based on corn. A combination of tax rebates, blending mandates and import protection has boosted corn prices and expanded crop production on sensitive lands (Westcott, 2007). Higher crop prices increase the opportunity costs of participating in the Conservation Reserve Program, leading farmers to seek to opt out, and increasing the public expenditures required to achieve conservation goals.

**Improving the System**

The effectiveness of current conservation programs based on financial assistance can be improved through better targeting. However, this does not address the underlying shortcoming of a technology-based cost-share approach. Getting enough of the "right" farmers to adopt the "right" practices in the "right" places will require much higher payment rates; rates that are not constrained by practice costs. This would substantially increase program costs, and raise the question of whether it is appropriate to "pay the polluter" when a "polluter pays" approach is applied to other sectors of the economy. Alternative approaches that have been applied in other economic sectors deserve a look.

***Pay for Performance***

Performance-based instruments generally provide pollution control at a lower cost than technology-based instruments, as long as performance can be measured at a low cost. The complex pathways and temporal variability of nonpoint pollution have been major barriers to performance measurement in agriculture. However, the continuing development of models for estimating changes in field losses provides an opportunity to give pay-for-performance a try. Such models are now considered acceptable by several states and by the EPA for determining the number of “goods” that can be bought and sold in regulation-driven water quality trading markets in the Bay watershed and elsewhere. Such models could be used in a pay-for-performance program.

Paying farmers for abatement would encourage those who can provide it at least cost to enroll in voluntary programs. Payments would not be limited by cost and would be paid for as long as abatement occurs, which make them more financially attractive than traditional cost shares. A drawback is the equity question: should taxpayers foot the bill? A compromise approach would be to establish a minimum performance baseline. Payments would be based on abatement achieved through practices that are implemented after baseline requirements are met. The states in the Bay watersheds have all used the TMDL to define minimum levels of performance in terms of best management practices employed, such as conservation tillage and nutrient management.

***Expanded Conservation Compliance***

Conservation compliance provisions require farmers to meet a minimum standard of environmental protection on environmentally sensitive land as a condition for eligibility for many federal farm program benefits, including conservation and commodity program payments. Compliance requirements are currently in place to protect highly erodible land and to prevent the draining of wetlands. Extending compliance to nutrient management by making program benefits contingent on following an approved nutrient management plan would provide an incentive to adopt best management practices (BMP) without imposing a burden on taxpayers. Compliance can be effective when those who receive the largest payments use the most polluting inputs—nitrogen, for example, and when the program benefits are greater than the cost of adopting best management practices. Data suggest that this is the case for fertilizers applied to cropland, particularly corn. However, the effectiveness of compliance is unpredictable, as total government payments can fluctuate with crop prices and disasters such as drought. Given the prospects of continued high crop prices and of reduced commodity program benefits due to budget concerns, mechanisms other than compliance provisions are probably needed.

***Regulation***

Water quality regulation has rarely been applied to agriculture in the United States. Currently, animal feeding operations designated as concentrated animal feeding operations (CAFOs) are subject to the permit requirements of the Clean Water Act. Regulated CAFOs—a small percentage of all animal feeding operations—are required to have a nutrient management plan that addresses the storage of manure and its application to land. A plan sets a limit on the amount of nutrients that can be applied per acre, and specifies erosion control measures to prevent the loss of sediment and nutrients. CAFOs that are not required to have an NPDES permit, but wish to claim the Clean Water Act’s storm water exemption for runoff from fields, must develop and implement a nutrient management plan to demonstrate that due care is being taken to minimize polluted runoff from manure spread on fields. If a waterway becomes polluted with animal waste from field runoff and a CAFO does not have a nutrient plan the farm would be in violation of the Clean Water Act. Of course, strong enforcement, or at least the expectation of strong enforcement, is necessary for this approach to work.

It is technically possible to apply a similar regulation to all farms. The Watershed Implementation Plans of the Bay States indicate that certain BMPs, such as cover crops and nutrient management plans, would be mandatory if sufficient progress is not being made with voluntary approaches. While mandating required technology is often viewed to be inflexible, a nutrient management plan is actually a very flexible tool, since it can be tailored to each operation. How effective the approach would be is questionable, however, since following a nutrient management plan does not guarantee that the desired environmental outcome will actually occur. The burden is on regulatory authorities to specify required practices that achieve environmental goals at least cost.

***Compliance Rewards***

Designing and enforcing economically and environmentally sound regulation for agriculture poses large challenges because of the spatial heterogeneity of agriculture production and its relation to the environment, the intra-annual temporal variability of agricultural production, and the large number of farms that an agency would have to contend with in permitting and enforcing regulations. While extensive regulation might be impractical, an effective use of limited funds could be to provide compliance rewards for farmers whose operations are inspected and found to be meeting or exceeding established standards of environmental protection on environmentally sensitive land. For this approach to work there would need to be a finite probability that a farm will actually be inspected. Effectiveness is likely to increase if penalties are applied to farms that are found to be in violation of established standards when inspected. Compliance rewards need not be solely financial. Many organizations use public recognition for high levels of performance—and sometimes the same approach for nonperformers—to increase the productivity of their staff. The same could apply to performance under environmental programs.

### *Water Quality Trading*

Regulations are most often applied to industrial and municipal point sources that are required to have a discharge permit under the Clean Water Act. The programs have been demonstrably inefficient. Trading programs have been developed recently in several of the Bay States and elsewhere in the United States, with a key objective of increasing the economic efficiency of pollution control by allowing sources subject to NPDES permits to trade abatement with each other and with nonpoint sources. From a farmer's viewpoint, trading is very similar to a pay-for-performance approach, the major difference being the source of payments. The track record for point/nonpoint trading programs is not encouraging. There have been a few successes, such as the South Nation River trading program in Ontario, Canada, but experiments to date are more often characterized by limited participation and trading activity. Market design issues, the characteristics of nonpoint source pollution, and farmer reluctance to enter into contacts in a regulatory-driven program have limited the number of offset trades that have actually occurred. It is an open question whether the apparently high transactions costs of point/nonpoint trading will ever allow it to become a major component of pollution abatement policy. Pennsylvania and other Bay States' trading programs are key tests of the potential of trading to improve the efficiency of water pollution control. Agencies developing water quality trading programs have focused on rules to assure environmental compliance. Essential to the success of water quality trading will be investments in the development of the markets and market institutions to reduce transactions costs and reduce perceived risks to participants.

Moving from the partially capped to a fully capped trading model that includes nonpoint sources would be one way of stimulating both farmer interest and innovations in tools or program designs that reduce transactions costs. This extension would, however, entail many of the public sector transactions costs that make extensive technology-based regulations unattractive for agriculture. It would also test the limits of political and legal acceptability of models used for estimating agricultural emissions.

### *Manure Markets*

Another potential role for markets in the Bay region is to improve the regional nutrient balance. Specifically, manure markets could be used to incentivize a redistribution of manure from surplus to deficit locations. This mechanism has been demonstrated in the Netherlands and has been receiving attention in the Bay watershed. Demand exists for manure and manure by-products in nutrient deficit parts of the watershed, but the economic value of manure to recipients relative to the cost of hauling currently limits the geographic scope of markets. Like water quality markets, the development of effective manure markets would require regulatory drivers—restrictions on the application of surplus nutrients—and public investments in market development.

### *Taxes*

Input taxes have several desirable features as a policy tool, and have been used to manage agri-environmental problems in several European countries. They have low public and private transactions costs. Input taxes induce innovation and encourage farmers to manage input use more carefully. Input taxes also generate revenue that can be used to offset the costs of providing targeted incentives for improving environmental performance to farmers. However, environmental taxes of any type carry considerable political baggage that makes them an unlikely tool in this country for the foreseeable future. Since the tax is on an input, the actual environmental outcome is also uncertain. Performance would be improved if environmental performance could be taxed, but this greatly increases transactions costs.

## Where Do We Go From Here?

Meeting the water quality goals laid out by the Bay TMDL will require greater effort than to date. More financial resources for conservation programs and improved targeting will help, but that will probably not be enough. State and federal water quality managers need additional tools to see the Bay program through.

Some type of pay-for-performance approach may be the easiest to implement, possibly as a pilot program. Modeling tools currently being used in water quality trading programs could be used to estimate farm-level abatement, and appropriate payments made. The potential for enhanced incomes should provide a greater incentive to farmers than traditional cost shares. If successful, federal conservation programs could move in this direction.

One step that states could take to influence farmer decision-making is to put in place credible backstop regulations. Regulations on fertilizer use or management practices would be implemented only if voluntary approaches fail to produce the desired outcomes. A “safe harbor” provision that protects farmers from future regulations if appropriate management practices are adopted would be an added incentive.

State and federal governments can work together to remove bureaucratic barriers that hinder cost-effective approaches. For example, EPA and the states could agree on a standardized baseline for water quality trading. This could open the door for trading between states, which could increase the volume of trades and improve market efficiency. As it stands now, different baseline rules are a major obstacle to interstate trades.

Another area where a regional solution could provide a big payoff is the disposition of animal waste. A coordinated effort to move manure to areas within and outside the watershed where it can be safely applied to the land would likely be less costly than letting each animal operation deal with the problem independently. In addition, finding other uses for manure, such as energy production, would improve the overall nutrient balance of the watershed and reduce the pressure on all other pollution sources. Ideally, markets in these areas would develop that would not need taxpayer support, but in the interim the benefits of public involvement might be worth the cost.

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# REGULATING FARMERS: LESSONS LEARNED FROM THE DELMARVA PENINSULA

**Michelle Perez**
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The experiences in three Chesapeake Bay states—Maryland, Delaware, and Virginia—which enacted mandatory nutrient management plan regulations in the late 1990s, provide important lessons for all six Bay states as they choose strategies to meet the new Bay water quality goals for nitrogen and phosphorus. A series of fish kills on the eastern shore of Chesapeake Bay in 1997 that drain the Delmarva Peninsula were linked to agricultural sources of nutrient pollution, specifically poultry manure. The fish kills were associated with *Pfiesteria piscicida*, a toxic microorganism which caused skin lesions on fish and health problems for fisherman and scientists studying the problem. Though the *Pfiesteria* diagnosis remains controversial to this day, the fish kills became a focusing event for the on-going and long-time plight of the Bay and prompted sufficient concern for all three states to augment their voluntary approaches to agricultural environmental management with new regulatory mechanisms.

All three states required farmers to obtain and follow field-specific nutrient management plans that "optimized crop yield by minimizing environmental losses of nutrients." Plans prescribed the rate, form, timing and method of application of commercial fertilizer and manure sources of nitrogen and phosphorus. In addition, the states decided to officially lower their university recommendations for poultry manure application rates from a nitrogen-based rate to a phosphorus-based rate to address the build-up of excess soil phosphorus in cropland in poultry production areas.

This article provides highlights from research (Perez, 2010) examining the Maryland, Delaware, and Virginia initiatives based on interviews with 60 farmers and over 60 policy stakeholders in the three states and other data. It examines the results of these initiatives according to two compliance criteria, administrative compliance and adherence compliance. The former is concerned with whether farmers obtained the required plans and filed the required annual implementation reports. The latter is concerned with whether farmers are following the application rates in their plans and implementing nutrient management practices. In addition, the article explores how implementation issues related to the policy processes in each state affected the outcomes.

### Different State Policymaking Processes

Maryland responded first to the fish kills. Its policymaking approach to regulating farmers was contentious. Under the leadership of a high-profile governor who was recognized as an environmental "policy entrepreneur," Maryland debated the causes of the fish kills and the possible policy responses under national news coverage. The media spotlight exacerbated the belief by farmers and farm trade associations that they were wrongfully attacked for causing the fish kills. They reported feeling alienated from the policymaking process and believed they had less influence than the environmental stakeholders. Maryland chose a very aggressive implementation schedule requiring almost all farmers to have a plan within three years of the law despite a shortage of State-certified individuals to prepare the plans and not having finalized their new policy on phosphorus management or the computer model used to calculate the plan recommendations. Maryland also required the poultry integrator companies such as Tyson and Perdue to add an enzyme, *phytase,* to their chicken feed to lower the phosphorus content of the poultry manure and to pay for 50% of the cost-share to transport excess manure off of farms.

In contrast, Virginia's business-oriented governor took a "go slow" approach, preferring to see if the fish kills would occur near the Western Shore of the Bay closer to the Virginia mainland, and to conduct their own medical analysis of the humans affected by the event. Despite leadership from a member of the state General Assembly who argued that a comprehensive regulatory response was warranted given that poor Bay water quality continued to cause harm to his seafood industry constituents, the Virginia General Assembly disagreed that regulating all farmers was necessary. Instead, Virginia chose to regulate only poultry growers—as the largest dairy and beef industries were already regulated. Crop and grazing lands were untouched. But because most poultry growers did not grow crops, Virginia provided very little cost-share to help farmers obtain a nutrient management plan nor did they establish a manure transport program as most of the manure was already moving from poultry farms to crop-only farms. In the end, environmental stakeholders in the state complained that the agricultural industry had the upper hand in the policy-making process. This resulted in a law that in effect, required very few farmers to make behavior changes that would result in significant nutrient reductions.

Because Delaware has no Bay frontage, the State waited to see how Maryland and Virginia would respond to the fish kills. Delaware's governor reached out to leaders in the agricultural community and asked them to discuss options for policy responses. They concluded that a comprehensive regulatory response was necessary by the state legislature but that a quasi-governmental commission comprised mainly of farmers be created to write, implement, and enforce the regulations. Thus, Delaware was highly inclusive of farmers and their farm trade association representatives in the policymaking process, to the point where they were seen by some as dominating the process. Delaware's policy deliberations largely occurred outside the media glare and behind closed doors. Delaware chose a very slow implementation schedule allowing farmers to come in voluntarily to obtain a plan within three years after the law or be called to comply in groups of 20% of the farming population over five years after the initial voluntary period. Though virtually all farmers were regulated, similar to Maryland, Delaware opted for a simpler and more straightforward phosphorus policy—a 3-year crop removal rate—which does not require field-specific measurements like Maryland's Phosphorus Site Index approach. Delaware provided farmers with cost-share funds to hire certified private sector planners if they chose to do so and established a publically funded manure transport program.

**Administrative Compliance**

Farmers in Maryland and Delaware reacted very differently to their state's regulations. While all Maryland farmers were required to develop a nutrient management plan by the first deadline in 2001, only 30% did so. In contrast, only 20% of Delaware farmers were *required* to obtain a plan by the state's first deadline in 2003, but over 40% of the eligible acres did so. Thus, while most Maryland farmers were "digging in their heels" according to many interviewed policy stakeholders and farmers, Delaware farmers were coming in early.

By 2008, however, the story changed. After years of sending warning letters and levying small fines to farmers who had not obtained a nutrient management plan, Maryland was able to gain virtually total compliance with farmers obtaining a plan and filing short, two-page Annual Implementation Reports. In contrast only 70% of the eligible acres required to come into compliance in Delaware had done so in the fifth and final year of implementation of the Delaware law. In addition, less than 40% of the expected Annual Reports have been submitted. In both instances, the Delaware Commission has made little effort to compel noncompliant farmers into compliance and only a "handful" of fines were levied. Thus, Delaware's seemingly more farmer-friendly approach did not achieve the same level of compliance over the longer term as Maryland's stricter approach.

Virginia's administrative compliance story is uneventful as virtually all poultry growers were in compliance by the law's 2001 deadline. Part of the ease of gaining near complete compliance was the fact that most growers didn't need to have a nutrient management plan written for them as they were not growing crops but only needed a manure transfer plan indicating which crop farmer was receiving his/her poultry manure.

In addition to the differences in administrative compliance statistics between states which can be attributed to the different state policy making styles and regulatory choices, there were also differences in farmer attitudes about their plans and their state regulations. The majority of regulated Maryland and Virginia farmers interviewed were critical of required nutrient management plans, believing they were too strict and that they would reduce yields. In contrast, the majority of Delaware farmers reported the opposite feelings; that they would be satisfied if they followed their plan; that their recommendations were not too conservative and the regulations were not too strict. It is uncertain whether farmers in Delaware have plans that are significantly different from farmers in Maryland and Virginia which may account for the different views on the plans by each group of farmers.

One factor behind some farmers' objections to their state nutrient management laws and the mandatory plans was that they did not believe they were over applying nutrients. Most farmers disagreed with the restrictive "Sufficiency" approach to nutrient application philosophy espoused by Extension scientists and preferred the "Maintenance" approach espoused by the private crop consultants and fertilizer dealers. In addition, many farmers did not believe in the new science that said phosphorus was soluble under certain conditions and could cause environmental harm even if soil erosion was controlled. The resulting phosphorus-based nutrient management plans were very unpopular, in that they restricted manure applications to the point where farmers have to purchase commercial nitrogen. In addition, farmers objected to the amount of "paperwork" that goes into preparing a nutrient management plan: obtaining soil survey maps, collecting soil tests, manure tests, keeping records of crop yield for every field for five years, and keeping records of the rate, form, timing, and method of application for each crop in each field. Many farmers indicated that it was too tiresome to manage each field differently and preferred to lump management of several fields together despite the different field characteristics. And, perhaps most importantly, farmers objected to the first step in a plan aiming to "optimize yields" which is to set a realistic yield goal for each field based on an average of the best three out of five years of yields, as they preferred to fertilize at levels needed to "maximize yields."

**Adherence Compliance**

Despite objections to the requirement for a nutrient management plan, many farmers across all three states indicated they have improved various aspects of their nutrient management behavior since the regulations were enacted. Among the most important improvements reported by farmers are: a) reduced purchases of commercial phosphorus fertilizer, b) reduced nitrogen concentrations in their purchased fertilizer mixes, c) reduced poultry manure application rates, and d) increased use of soil nutrient and manure nutrient testing. Even the Virginia crop farmers who use poultry manure but are not required to implement a nutrient management plan said that they have "a greater awareness of nutrient management" because of the laws applied to their poultry grower neighbors.

However, many basic nutrient management practices that have been encouraged for decades by each state's University Extension Service and federal Conservation Districts are still not being used by a majority of the farmers. These include: a) not taking residual nitrogen credits for previous legume crops or applied manure; b) not implementing a riparian set-back from ditches or streams when driving manure spreaders—resulting in manure deposition into waterbodies; c) disposing of manure during winter months when no crops can absorb the nutrients, making them subject to significant environmental losses; and d) not calibrating manure spreaders at least annually.

In addition, most farmers disagreed with the scientific consensus that "agriculture is the largest source of nitrogen and phosphorus loads to the Chesapeake Bay." Previous research has found that farmers have to believe that a problem exists before they accept that best management practices are justified and are willing to take action (Ribaudo and Horan, 1999).

Each state experienced difficulty during on-farm inspections in detecting adherence with the nutrient management plans and resorted to using mathematical calculations based on fertilizer receipts and manure transport counts to determine compliance. Virginia committed to inspect all regulated poultry growers, and on average they accomplished a 90% inspection rate and about an 80% compliance rate. Both Maryland and Delaware set a 10% inspection goal and both fell short, Maryland inspected about 8% of regulated farms per year and Delaware inspected only two percent. Delaware found that about 80% of the inspected farms were in compliance while Maryland found that only about 65% were. The majority of the noncompliance was attributed to having an outdated plan which indicated that a third of the inspected farmers were not valuing their plan sufficiently to update it.

Finally, there is some concern about evasion of the law. During my interviews, about 15% of farmers in all three states happened to use the same three private crop consultants who are certified by the states to write nutrient management plans. These farmers and one of the crop consultants described several ways they are actively evading their state laws. For example, several farmers told me they are keeping "double books"—one nutrient management plan to show inspectors and one plan to use themselves. Other farmers said they were setting their crop yields higher than their average yields in order to justify higher nutrient application rates and several farmers said they knew they were applying higher manure rates than they should be. This anecdotal evidence for the ease of noncompliance with a mandatory plan underscores the herculean challenge before state policy makers. Given the nonpoint source nature of nutrient pollution, the challenge of detecting and attributing nutrient pollution to individual farm fields and farmers, the challenge of determining the validity of a plan, and the challenge of detecting adherence with a valid plan, the only way for governments to ensure with some certainty that farmers are following their plans is if farmers believe it is in their best economic interest to do so.

**What does this mean for the Bay Total Maximum Daily Load (TMDL)?**

As the EPA and the six Bay states grapple with how to accomplish the new TMDL cap on nutrient and sediment pollution to the Bay, which will likely involve even more intensive management and edge-of-field practices by the agricultural sector, several policy recommendations for the Bay States can be drawn from these experiences.

First, states should better understand the top reasons why some farmers do not follow university-standard nutrient management plans, including: a) poor acceptance of the links between agricultural activities and water quality problems, b) disagreement over the approach to setting yield goals: optimizing versus maximizing, c) disagreement over the Maintenance versus Sufficiency nutrient application philosophies, and d) poor acceptance of crop and soil nutrient science concepts—such as soil phosphorus concentrations and soluble phosphorus.

Given that the majority of farmers across all three states indicated that they were "interested in receiving more educational materials about nutrient management-related topics" and that they "believe that protecting the environment is part of what it means to be a farmer," there is an opportunity to address perspectives that result in unintentional nutrient losses from agricultural production. A better understanding of their contribution to water quality problems in the Bay may make farmers more willing to be active collaborators in the Bay clean-up process.

In order to encourage adoption of nutrient management practices and to facilitate compliance, state university scientists and economists should collaborate with Soil Conservation District personnel, state regulatory agencies and other appropriate parties such as farmer peer-to-peer exchange networks to confirm whether the aforementioned problems are those hindering compliance with nutrient management plans or adopting good practices. Then, these stakeholders should develop unprecedented, specifically tailored education campaigns, including economic analysis that shows the savings and costs from adhering to university recommendations and other good practices. Policy stakeholders should consider coupling these tailored outreach campaigns with focused financial assistance to help improve farmer nutrient management behaviors.

Second, since over a decade has passed since the laws were enacted, it is time for states to evaluate if their approaches for gaining farmer compliance are effective. All three states should consider more frequent and effective farm inspections and significant fines to make noncompliance more costly than compliance.

Third, states should recognize that since the solutions to nonpoint source agricultural pollution largely involve behavioral changes rather than “end-of-pipe” technology solutions, states should focus on gaining buy-in from farmers for the new level of environmental management needed to achieve the new clean water goals. Note that such a collaborative process could be voluntary or regulatory in nature. However, states have to balance the goal of gaining buy-in from farmers and farm associations with the goal of achieving the new level of environmental management needed to meet the new clean-up goals.

Fourth, regardless of whether new regulatory options or new tailored outreach and voluntary programs are considered, states should opt for achieving changes that will have a major environmental impact, as was the case with requiring the addition of *phytase* to chicken diets. In addition,states should attempt to disaggregate the new Bay nutrient pollution reduction goals into smaller goals achievable at a watershed-scale for groups of farmers to accomplish and even at farm or field scales for individual farmers.

Fifth, if a regulatory approach is chosen, states should opt for easily monitored and verifiable practices to reduce the uncertainty of detecting compliance during on-farm inspections.

Sixth, financial assistance to implement regulations will likely be critically important to fully implement new rules. However, given the current budget crisis, states should prioritize cost-share funds for activities that are the most cost-effective.

Finally, whatever new policy approaches states engage in to meet the new clean water goals, states should establish realistic implementation schedules that reflect government and private sector capacity to deploy the new programs.

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# ENVIRONMENTAL SERVICES PROGRAMS FOR THE CHESAPEAKE BAY

**Leonard Shabman, Bob Rose, and Kurt Stephenson**
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Keywords: Ecosystem Services, Payment for Ecosystem Services, Water Quality, Chesapeake Bay

In December 2010 U.S. EPA published a Chesapeake Bay Total Daily Maximum Load (TMDL) defining the maximum allowable loads for nitrogen, phosphorous and fine sediment. The load reductions expected from various sources is described in Watershed Implementation Plans (WIPs) for six states and Washington, DC. The WIPs recognize that regulated "end of pipe" point sources contribute only a fraction of the total load and so include programs to limit diffuse and weather dependent loads from agriculture and low density suburban development. In general, WIPs expect agricultural land owners to implement pre-approved best management practices (BMPs) in return for payments that will offset a share of the cost to install those practices. Some states regulate the nutrient content of lawn fertilizer. However, the strategy for low density suburban lands centers on education programs to encourage suburban land owners to be "Bay friendly" in their landscape management and waste disposal behaviors.

The need for on-going adjustment of the WIPs is expressed in 2-Year Milestones that will be a check-in to assess WIPs effectiveness in meeting load reduction expectations as well as securing living resource goals such as fish and shell fish population increases and public access and use of the Bay's waters. Among many observers the concept of Payment for Environmental Services (PES) programs has drawn attention as a new way forward. Indeed, at the federal level the PES language has been embraced by the USDA and the USEPA.

The Northern Everglades Payment for Environmental Services Program was adopted as a template for an operating PES program (NE-PES) The Florida example was chosen for two reasons. First, it is a unique and fully functioning PES program for working lands . Second, the first author of this paper was instrumental in the design and launch of that multi million dollar program. (Lynch and Shabman, 2011). Based on that template, we define a PES program as one where there are contracts between a buyer of environmental services and individual landowners who agree to offer environmental services, above regulatory requirements, on agricultural and suburban lands. Payments for the services provided are made at contract specified intervals, such as at the end of a year, only when the seller can document that the services have been provided and the documentation is verified by the buyer. In our judgment the Bay's landscape, land use, and land ownership patterns will make implementation of a Florida-like PES impractical. However, the principles of PES can be adapted to the Bay circumstances and can make a significant contribution to Chesapeake Bay management. This adaptation is called the "Recognition for Environmental Services Program" (RES).

**Recognition for Environmental Services**

Below is a vision of how RES programs might operate. We begin by recognizing that the 64,000 square mile Chesapeake Bay watershed can be subdivided into thousands of "catchments". Each is a small watershed that varies in size from less than 1 square mile to 10 square miles. These small catchments have a single location where the rainfall on the catchment drains to a larger stream or to the Bay itself. Land uses in the catchments are of all types that exist in the Bay watershed, but due to the small size land uses are more likely to be uniform within the catchment. In a RES program land owners in a catchment would cooperatively produce nutrient and sediment reductions that benefit the Bay and estuaries, in support of the living resources of the Bay and in support of improving the environmental conditions in the catchment itself.

Catchment organizations would be formed to include landowners and would use low cost measurements to document pollutant load reductions in the catchment. The organizations would "contract" with new state-level RES programs which would formally acknowledge these catchment organizations, verify their documented water quality changes and provide financial payments to offset costs, cash prizes and other recognition to landowners through the catchment organizations. The state RES programs could be funded by dedicated fees and general revenues, but would be created and operated outside of any existing agency or program. Alternatively, the RES concept might be applied at the local level, for example a storm water utility might recognize and reward households in a catchment with rebates on their utility bill for documented load reductions.

Technical and financial cost share assistance for imagining and implementing load reduction actions would be available through traditional programs to support the new state RES program. The actions can be on individual land parcels or can be community actions such as stream and wetlands restoration. RES recognitions would be cash prizes and noncash acknowledgments. The prizes would be lump sum payments to an organization, but would not be based on a formula that links the size of the prize to the precisely measured service levels, for reasons described below. Non cash recognitions can include, but are not limited to, awards, positive publicity, or priority in grant programs of other agencies. Local watershed improvement benefits—other environmental services—realized coincident with Bay-specific water quality improvement outcomes would be emphasized, increasing the commitment of landowners and communities to actions that would also serve the Bay-TMDLs. For that reason, RES program results should be documented in terms of downstream outcomes, or loads, and local water quality conditions. .

Of special note is that the RES emphasis on documentation creates a learning opportunity, a benefit essential to water quality improvement. To appreciate the need for a program that supports learning and how learning occurs consider some analogies. When consumers buy food, they learn from experience what they enjoy. When companies adopt new production practices, they observe how output quantity and quality changes. When entrepreneurs invest in new product development, they test the viability of their ideas with consumers in the marketplace. The common feature in all these examples is a feedback loop: a decision is made with an expectation of a desired outcome, realized outcomes are compared to expected ones, and future choices are modified based on what is learned about the outcome and the causal linkage between the decision and outcome. Such a feedback loop rarely is in place when the decision is controlling nutrient loads and providing other environmental services. With the exception of regulated point sources—which regularly sample and monitor effluent and can link technical changes, individuals and communities are expected to make choices—sometimes quite costly ones—without any feedback on what environmental outcomes those choices produce. Farmers, developers, and local governments implement runoff control BMPs without any observable indicator of how nutrient loads change or how water quality is or isn't improved. A positive environmental outcome might be viewed as a reward for bearing a cost of an action and can motivate further actions, but outcomes are rarely measured and reported in ways that are linked to the decisions made and reported in terms that are meaningful to those who make the decisions—there is no feedback loop. Instead, the only observable outcome to those being asked to implement nutrient control practices is the cost they bear. The creation of a feedback loop must be the focus RES design.

**Getting to RES**

There is no exact application of the RES program concept anywhere in the nation, although elements of the envisioned state RES programs can be found in PES and some cost share programs. Therefore, creation of operating RES programs must be preceded by a refinement of key ideas with on-the-ground demonstration projects. In parallel, there must be a process, with strong leadership, to engage all stakeholders—agencies, NGOs, landowners, communities—who together design a program that yields environmental results and is feasible to administer. That process must be linked to the demonstration areas so that there are concrete examples to inform the conceptual design discussions. This was the lesson of the Florida Ranchlands Environmental Services Project experience.

An average county in the Bay may contain a few hundred catchment watersheds, thus providing an ample array of potential places for the RES development and demonstration effort. The WIPs greatest need is to address loads of nutrients and sediment from agriculture and low density suburban land uses, as these sources create significant loads which would be difficult to regulate following the traditional regulatory structure. Therefore, catchments that have agricultural—crop and pasture—and low density suburban land uses, and have no point source discharges, would be the preferred areas for the early development and demonstration of an RES program. In many of these places watershed groups already exist, so having organizations in place may be a criterion for selecting a catchment for the demonstration program. Several general concepts for an RES program would be further refined in the development and demonstration phase and each demonstration catchment would be an experiment to inform the collaborative design process. The development of a RES program hinges on two critical elements: development of a workable environmental measurement to serve as the informational feedback loop and functional catchment organization.

**Develop Environmental Service Measurement Methods**

It is often argued that it is impractical to measure loads and reductions in load achieved by individual diffused sources. The default has been to promote the implementation of prescriptive BMPs that assume a fixed effectiveness of those BMPs over time, with little or no monitoring of results or even the maintenance of those BMPs. This approach to implementation persists in the WIPs, we believe, because few if any alternatives to address the measurement challenge have been put forward. RES catchment associations will have an incentive to measure water quality changes. Because roughly 70% of catchments feed a single stream with a single exit point, monitoring at a single point makes measurement technically and administratively feasible. Because cost must be low, the goal of that monitoring would be documentation of the load reduction and other environmental services that is “good enough”. Good enough is when both the RES program and the watershed catchment service providers have sufficient trust that the provision of the recognized services is being realized.

RES can rely on a limited number of metrics that are proxies for services provided. The demonstration catchments would be expected to measure certain outcomes and relate those outcomes to Bay load changes and to local watershed conditions. In all places the goal will be to select the fewest number of metrics needed for documentation of water quality changes and to assure that the measurement plans give priority to cost and ease of measurement. Such measurements might include temperature, turbidity and changes in river stages, with analyses made to relate these measures to nutrients leaving the catchments, local fish habitat support or bacteria levels which determine suitability for water contact recreation. In all cases the reporting will be by the catchment organizations and the measurement and reporting methods should require real time “hands on” responsibility. There may be remote measurement and data transmission technology, but that technology cannot get in the way of people’s connection to the catchment and “seeing”, through the measurements made, the results of their actions. In that way, measurement can feed back to community action. For example, seeing spikes in sediment load during a rain event can lead to walking back up stream to find the sources of the sediment and then working with landowners to control the runoff.

**Create Model Catchment Organizations**

The Florida PES program is based on a one-on-one relationship between the entity paying for the service and individual landowners. Bay agriculture is characterized by small land holdings and part time agricultural operators. At the same time many catchments’ land use is low density with dispersed homes and much turf. A program that expects a state RES program to directly “contract” with this diverse array of landowners would be administratively infeasible.

In an RES program, “catchment organizations” serve as an intermediary and coordinator between the RES program and providers of load reduction services. Landowners within a catchment, acting in concert through a catchment organization, jointly produce water quality improvements—nutrient and sediment reductions—that benefit the Bay and estuaries by meeting the TMDL. Watershed catchment organizations would be expected to secure commitments to land and water management from small agricultural land owners and suburban land owners. In order to develop broad-based local support and credibility, the organizations would be developed and managed by local citizens and be independent of any advocacy groups—environmental, agricultural, and so on.

Many actions like lawn grooming and fertilization practices do not result in any out of pocket expenses, but would be particularly amenable to local education and oversight by the watershed group. If costs are required, the organizations could apply on behalf of the individuals in the catchment for technical support and financial assistance, and would be able to provide that assistance themselves. This same organization could motivate community scale as opposed to individual actions, such as stream restoration.

As described above, the organization would document the load reductions using low cost measurements of water quality improvements attributable to the RES program. However, by virtue of its relationship with the land owners, the catchment organization would be aware of the landowners who made the improvements that earned the recognition for the RES and could appropriately distribute any RES cash prizes and recognitions to landowners in the catchment community. We believe collective uses of such funds and social acknowledgments at the community scale could be a powerful incentive to action.

In contrast, a PES is based on the admittedly unrealistic assumption that financial payments linked to environmental services provided are not only a necessary, but also sufficient, incentive for landowners to provide services. In the Bay watershed the land holdings are small, the uses are varied, the farmers are part time and many of the required actions will be on suburban landscapes. Therefore, RES would still require cost share to offset some costs which may be required to motivate action. However, an RES organization would also receive cash prizes and noncash recognition on behalf of landowners within a community, with the expectation—to be discussed and tested in the demonstration phase—that recognition from outside can motivate action by communities and individuals.

Downstream Bay concerns about nutrient loads should not dominate the agenda of the catchment organizations. To generate local support and commitment, catchment organizations will increase attention to and recognition of locally important watershed improvement benefits that will motivate cooperative action by also emphasizing local efforts to improve local water quality conditions such as sediment loads and habitat. These efforts will produce local benefits including increased stream access, improved aesthetics, more frequent opportunities for water contact recreation from reduced bacteria loads, and fishing which depends on the flow regime.

The literature in behavioral economics, anthropology, and sociology—especially community organizing, and other disciplines offers evidence that communities of individuals can and do organize themselves to meet a common goal—in this case an environmental outcome—even if the benefits of that outcome do not always align with those who bear the costs. Eleanor Ostrom (2010) summarizes one strand of that literature as follows: "The crucial factor is that a combination of structural features leads many of those affected to trust one another and to be willing to do an agreed-upon action that adds to their own short-term costs because they do see a long-term benefit for themselves and others and they believe that most others are complying."

The way that a catchment organization would form and function will differ, perhaps radically, by land use and owner characteristics. Therefore Ostrom's general statement can be made operational for an RES if the demonstration phase develops model organizations for suburban land owners, crop farmers and cow–calf pasture operations. The models will need to accommodate different business objectives, such as profit or "hobby farming", and different demographic characteristics of the landowners because the diversity of landscapes in the Bay catchments is matched by the diversity among the land owners themselves.

**Concluding Observations**

Realistically, a wholly new program does not emerge based on a "better" idea—nor should it. Innovation demands a demonstration that a different way forward is administratively feasible and will yield superior environmental results. As such, the feasibility and merit of RES programs for the Chesapeake Bay watershed must be tested and debated, supported by a field demonstration, and vetted through a stakeholder design process.

Such a process will require financial support, recognizing that in the current budget setting where existing agency program budgets are being frozen or reduced, it is not likely that significant revenues will be made available for the design of a demonstration program. However, some watershed innovation grant programs in the USDA and EPA may be employed, particularly if matched with support from a nonprofit foundation. The funds for such a process will be needed to support the testing and development of the monitoring protocols and to motivate and then provide leadership to the collaborative process itself.

Before a collaboration process can begin, there must be mutual trust among those who would be expected to participate in that process. Current circumstances surrounding the Bay TMDL and WIPs as of this writing have not yet fostered complete trust by all parties. Here again we believe that the small scale of these catchments offers opportunity. We believe the small size of such catchments, roughly the same scale as one might push a stroller or walk their dog is key to establishing necessary dialog and trust within each catchment community. Because there are literally tens of thousands of these catchments, certainly a few hundred exist where a critical mass of landowners would be interested in trying. And we believe in turn that recognition and appreciation at such community scale can be no less powerful than cash payments.

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# ALLOCATING POLLUTION LOAD REDUCTIONS BETWEEN STATES FAIRLY, EFFICIENTLY AND SUCCESSFULLY

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The successful implementation of pollution load reductions to clean up the Chesapeake Bay involves solving multiple ecological, economic, and political problems. While issues such as determining the environmental impact of particular load reductions or providing the appropriate economic incentives to agricultural producers have been discussed extensively, little attention has been given to how to consider the political realities of making decisions over load reductions in a representative democracy and federal system of governance.

Since Downs' (1957) seminal paper developing a spatial model of voting, political science researchers have developed increasingly sophisticated models of political decision making. Krehbiel (1988) or Ordeshook (1986) offer more thorough reviews of formal modeling of the political process. The objective of this article is to highlight how the political process might impact the ultimate implementation of pollution load reductions. By incorporating models of political decision making into the design of institutions governing these reductions, we may be better able to create an effective and efficient clean up of the Chesapeake Bay that survives the political realities in both Washington, D.C. and the various state capitols involved in the process.

The consideration of politics in the design of pollution load reductions for the Bay area watersheds faces two important challenges. First, given the current economic climate at both the federal and state level, there is unlikely to be substantial political support for regulatory policies that either hinder economic growth or adversely impact the fiscal position of either the states involved or the federal government. Indeed, the balanced budget requirements of most states and the increased interest in debt reduction at the federal level means that environmental regulations will not be able to rely upon substantial funding to encourage proenvironmental behavior. This may impact the success of environmental regulation in a number of ways. While efficient policies may be enacted using either transfers to or from states, both policies might faces significant fiscal hurdles at either the federal or state level. Further, the effectiveness of environmental regulation also depends upon substantial funding to monitor and encourage compliance. Limited budgets may constrain the funds available for the implementation of these policies.

Second, the United States' Federal system of government provides substantial autonomy to individual states. While the Federal government through the EPA and other agencies has the ability to impact policy decisions at the state level, they are also reliant upon the willingness of political leaders within the states to enact certain provisions. For example, while the Environmental Protection Agency (EPA) generally has the ability to regulate point source producers of pollution such as large factories or power generation facilities, the ability of the EPA to regulate the actions of nonpoint agricultural producers is dependent upon coordination at the state level. While fiscal issues cannot be denied, the focus here is on the second problem of navigating the complex political world of multiple political jurisdictions.

**What Is Efficient?**

The policy of designing pollution load reductions to clean up the Chesapeake Bay is essentially a public goods problem; the action of one state to reduce pollution on its waterways will impact other states by providing cleaner waterways and a cleaner Bay. Therefore, an efficient policy should be one that assigns load reductions to states in a manner such that the desired level of Bay cleanup is achieved at the lowest possible cost. Importantly, since the load reductions of one state impact all other states, load reductions should consider the cumulative benefits and costs of such actions across states.

In this context, the efficient policy is likely to result in varying load reduction requirements across states. For example, while load reductions within one state may be highly effective from an ecological perspective, if the cost of enacting those reductions is extremely high, it might pay to ask for reductions from a less ecologically effective but economically cheaper region. Second, since states are not equidistant to the Chesapeake Bay but all states are likely to be required to make some load reductions in the efficient solution, the benefits of the overall policy is likely to be different among states. Expertise on the ecology and economics of these particular states will be needed to provide further details regarding efficient choices. The key, however, is to recognize that the substantial differences between states in geography and other factors is almost certain to mean that the benefits and costs of an efficient program will be highly asymmetric between states. The EPA's "Chesapeake Bay TMDL Executive Summary" provides a description of how load reductions in different regions would impact the Bay.

It is well known from the economics literature, that when an individual—or state in this context—does not face the full benefit or cost from the ecological improvement of the Bay and, they have an incentive to "free ride" or under-provide load reductions from the efficient amount.  For example, an industrial facility that releases pollutants into the watershed in an unregulated system does not have an incentive to reduce those emissions because, while they must pay the full costs through increased costs of production, they do not receive the benefits received by downstream parties from an emissions reduction. Olmstead (2010) reviews regulation issues related to water quality. Sigman (2005) empirically validates such a result by showing that downstream pollution is generally higher.

However, it is possible to design a system of payments—or possibly charges—to provide each individual the appropriate incentives to take the efficient actions. In fact, in an unconstrained world, the federal government has access to a variety of different regulatory policies that may achieve the efficient outcome.

Hanley, Shogren, and White (2007) provide a review of economic issues related to environmental policies.  As mentioned previously, fiscal constraints may limit the ability to rely on payment schemes to induce efficient load reductions. But, explicit taxes or subsidies are not absolutely necessary to achieve efficiency; Segerson and Wu (2006) show how efficiency can be achieved via the threat to punish noncompliant behavior. The second, and greater yet less studied, constraint is that any policy must rely on political acceptance and compliance by diverse states in a federal system of government.

**How Politics Matter**

The previous discussion of efficiency treats states as being the same as individual decision makers. Critically, with individuals, we typically assume that there is always some financial payment that can encourage them to take a desired activity. For example, to stop doing something deemed objectionable—such as smoking or polluting—all an individual would have to do is offer enough money. State decision making, however, may not be same as individual decision making. The difference comes from the fact that decision makers within a state—either legislators or governors—are elected officials who must acquire a majority of the votes from their electorate in order to remain in office. In order to win elections, state level politicians must support policies that are sufficiently amenable to these voters.

Downs (1957) provided a model of how electoral competition might impact policy making. Suppose that voters in a state only care about how proenvironment a particular candidate is. Some voters want a candidate who is very proenvironment whereas other voters prefer much less "green" candidates. Downs' theory predicts that the policy proposal of winning candidates—and eventually all candidates—will tend to the preferred stance of the median voter or the voter for whom exactly half of the electorate is more proenvironment and exactly half the electorate is less proenvironment. This median voter theorem comes from the fact that if a candidate does not support such a middle of the road policy then there will be room for a competing candidate to gain votes and win the election by offering a more centrist policy.

In this context, state level elected officials can only be expected to implement pollution load reductions that are at or near those of the median voter in their particular state. In the extreme, the preference of the median voter might be viewed as the ultimate amount of load reductions that can be implemented. In the least, the median voter in a state acts as a constraint on the level of acceptable reductions; states with a more proenvironmental median voter can be expected to support greater load reductions whereas states with less proenvironmental median voter will be loathe to support load reductions. The states involved in the Chesapeake Bay cleanup differ in their political attitudes toward environmental policy. For example, states in the Chesapeake Bay region differ significant in the League of Conservation Voters' (2010) Environmental Scorecard. Most importantly, as long as the political preferences of the voters are different than what is efficient, it may be difficult to implement pollution load reductions that achieve full efficiency.

A single-issue, say environmental, view of the political process is both useful and highly simplified. The reality is that any pollution load reductions are likely to impact voters on a number of dimensions. For example, load reductions are likely to impact the environment as well as the economy of a particular state by making agricultural production more expensive. Further, by allocating load reduction requirements differently between point and nonpoint sources, the proposed policy can be more or less probusiness or more or less proagriculture. Voters are likely to care about these issues differently but still are assumed to vote for candidates who enact policies closest to their preferred stance on all the issues. When a policy decision impacts multiple-dimensions, the median voter result no longer generally applies; Plott (1967) shows that only under extremely limited conditions does an equilibrium exist. Instead, generally any policy proposal can be beaten—by attracting a majority of the voters—by another policy proposal. Since alternative policies can attract voters by changing the stance on multiple fronts, the political candidate has enough freedom to pull voters away from his/her rival. McKelvey (1976) shows that the problem can be quite severe in the sense that an agenda of successive competing proposals can be designed to lead to nearly any spot in the policy space. Since pollution load reductions actually touch on many voter relevant issues such as environmental, agricultural, and business policy this negative result may indeed provide an explanation for the continuing difficulty in finding a mutually acceptable implementation plan.

**What Role for the EPA?**

The EPA has choices over policies that vary in their level of centralization. For example, they could select a uniform load reduction standard that ignores state heterogeneity and spillover effects, or they could completely decentralize the load requirements to the states making state level free rider effects problematic. As Oates (2001) discusses, the issue of cross jurisdictional effects from proenvironmental behaviors suggests that a tricky middle ground approach is necessary where some central authority is required to obtain efficiency but standards or policies must be asymmetrically applied. While the previous discussion of the political process may seem to provide discouraging results for the ability of the EPA to design policy that is both efficient and politically palatable to the states, it also suggest how the EPA can play a constructive role within the constraints of the political system. For example, if the EPA's role is seen as setting the status quo level of pollution load reduction and allowing states to negotiate amongst themselves for changes from those amounts, then the EPA's load reduction requirements can serve to limit the policies that a state's politicians might support. Likewise, when policies impact multiple dimensions, it is known that the process or institutions that govern the decision-making process can have a dramatic impact on the final outcome. The only way out of the chaos of multiple issues is to create limits on the agenda or process. Shepsle and Weingast (1984) provide an example in this context for what is commonly referred to as a structure-induced equilibrium.

Another positive role for the EPA in this context may be to represent the interests of the states not directly impacted by load reductions. While six states and the District of Columbia may be asked to reduce emissions and are mostly likely to pay the brunt of the economic cost of the policy, presumably the whole nation benefits from a cleaner Chesapeake Bay. Thus, the efficient level of load reductions might account for benefits accrued outside these seven decision makers and the EPA may play a vital role in this process.

However, while this discussion has focused on how state politics may serve to move decisions away from what is efficient, the EPA will ultimately face similar constraints at the federal level. Since Congress determines EPA funding, it must enact policies that satisfy a majority within Congress. While there has been surprisingly little recent research on this area, papers such as Shepsle and Weingast (1984) and Romer and Rosenthal (1978) deal with the issue of how collective, public goods decisions are made within the political process and suggest that the outcome may be far from efficient.

**Other Considerations**

The political process is only the tip of the iceberg in thinking about how a group of independent states may arrive at a common policy decision. There are a number of other factors that might impact the ultimate outcome that have not traditionally been considered. A few are briefly mentioned here.

Economists increasingly recognize that even individuals fail to behave as rational as traditional economic models suggest. In particular, people care considerably about the perceived fairness of an outcome (Bolton and Ockenfels, 2000); individuals will typically reject profitable but highly inequitable offers. Since the efficient level of load reductions might entail highly asymmetric cost and benefits between states, the perceived inequality of this policy might be another roadblock. On the positive side, there is also ample evidence of pure altruism amongst individuals, which might ameliorate some of the negative feelings associated with costly pollution load reductions.

On the political side, while multiple dimensions clearly matter to voters, the most salient issues often rule the day. For example, it is clear that economic and fiscal issues are driving decisions today, whereas some social and environmental issues might be in the background. State and federal elected officials will in their attempt to get reelected follow the desires of the voters on the most salient issues. Thus, if awareness and concern for the Chesapeake Bay cleanup grows in importance, elected officials are more likely to be willing to enact favorable policies.

Finally, the concerns expressed here treat the makeup of the state electorate as static and unchanging. In reality, voters and business are likely to move over time to states with policies that are most favorable to them. Just as banks tend to locate in Delaware because of its favorable banking laws, agriculture and industry may move over time to states with the least restrictive pollution load reductions. It is has often been suggested that interstate competition for firms might create a race to the bottom where states offer more lax environmental standards (Oates and Schwab, 1988). To the contrary, some research (Wellish 1994) actually suggests that mobility of households will move states to efficiency by forcing them to respond to the desires of individuals. However, these models make a variety of assumptions that are not likely to hold in this setting and would move us away from efficiency. For example, Haavio (2005) shows that mobility frictions can move policies away from efficiency. Much of the regulation of pollution load reductions for the Bay is likely to fall on agricultural producers and capital intensive point producers who are unlikely to be particularly mobile. This might ultimately create further asymmetries between states that can result in political resistance to cleanup of the Chesapeake Bay. Wilson (1996) provides a review of some of the results of this fairly large literature, but there are also few models that interact mobility, voting and environmental regulation.

**Concluding Comments**

While some of the discussion above may seem negative and suggest that the political process will only move us away from the efficient cleanup of the Chesapeake Bay, understanding the political realities of the situation is necessary to avoid past frustrations associated with failed but well-intentioned policies. While today's political climate may require more modest goals, by selecting policies that recognize these limitations there is a hope for some forward progress. Further, in this situation, where multiple dimensions are likely to be impacted by the cleanup, the main gains can be had by intelligently designing the process and institutions to arrive at solution when the players are state and federal elected officials.

Finally, while there has been some research attempting to understand how public good decisions such as environmental policy are made by elected officials, there has been little research that focuses on the process when there are multiple layers of political processes to contend with. In this case, it is necessary to satisfy both state and federal elected officials. It might also be necessary to engage elected officials at a third, more local level, which would even further complicate the process. Research which incorporates this multi-level approach to collective action problems could greatly improve our understanding of the difficulties associated with not only pollution load reductions for the Chesapeake Bay but also the Kyoto Protocol and other international agreements that must engage sovereign, democratic governments.

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