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DESIGN OF A NATIONAL NONPOINT SOURCE POLLUTION CONTROL PROGRAM: IMPLICATIONS FROM RCWP

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Control of point sources of water pollution in the 1970's and early 80's was not sufficient to meet national water quality goals. Additional measures have been necessary to control nonpoint sources of pollution. Agriculture is generally recognized as the primary contributor of nonpoint source pollutants. (Nonpoint Source Task Force).

This paper discusses implications for the design of a national agricultural nonpoint source pollution control program, based on an ongoing economic evaluation of the experimental Rural Clean Water Program (RCWP). Specific results of the economic evaluation are presented to illustrate the points that we wish to make. Details concerning data, models, and estimation procedures are discussed by Bouwes and Young; Carvey; Crowder and Young; Erickson; and Gum, Magleby, and Kasal. We proceed with a brief description of RCWP and the projects that we evaluated, followed by a discussion of the implications for the design of future programs that evolved from our evaluation of RCWP. The economic evaluation of RCWP demonstrates that by targeting specific locations nonpoint source pollution can be controlled and that the benefits of control can exceed the costs if impairments to water use affect a sizable number of people and costs can be minimized through applying the most cost effective practices.

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Rural Clean Water Program

The experimental Rural Clean Water Program was initiated in 1980 to demonstrate the effectiveness of an agricultural nonpoint source program. Approximately $60 million was allocated to 21 projects. These projects were selected to represent the range of potential agricultural nonpoint source problems. Farmers choosing to participate in the program were eligible to receive cost share funds for implementing practices to reduce pollution runoff from their land. Cost shares for these "best management practices" (BMPs) could range up to 75% of eligible costs with a maximum of $50,000 per farm.

Five of the RCWP projects received additional allocations to permit comprehensive monitoring and evaluation. These projects were: the Idaho Rock Creek Project, the Illinois Highland Silver Lake Project, the Vermont St. Albans Bay Project, the Pennsylvania Conestoga Headwaters Project, and the South Dakota Oakwood Lakes - Poinsett Project. The comprehensive monitoring and evaluation studies include both water quality and economic components. The water quality problems and use impairments originally identified for the comprehensive monitoring and evaluation projects are listed in Table 1, along with projected improvements in water quality.

In the Idaho project, high sediment levels in Rock Creek were identified as impairing recreational fishing in Rock Creek and downstream water storage capacity and power generation in the Snake River. The sediment loads were primarily attributable to sheet and rill erosion resulting from irrigation.

Irrigation systems are being modified and conservation tillage and sediment control structures are being installed to reduce sediment delivery. Preliminary evidence indicates that the quality of the water in Rock Creek is improving because of the RCWP but that the downstream effects on the Snake River are minimal.

In the Illinois Project highly erodible natric soils being carried off surrounding farmlands into Highland Silver Lake were identified as impairing municipal water supply and treatment and recreational fishing. RCWP erosion control practices appear to be decreasing turbidity levels in Highland Silver Lake. Sediment deposition is less than originally anticipated since the natric soils tend to remain suspended once they erode from the fields, and pass through the lake.

In the Pennsylvania Project, excess fertilization with animal manure and commercial fertilizer are degrading surface and groundwaters, impairing

Table 1 -- Water quality problems, impairments and expected improvements

Project	Water quality problem	Use impairment	Water quality improvements
Idaho	Turbidity, sediment	Fishing, water storage, power generation, ditch capacity	Major reduction in sediment in Rock Creek Minor improvements in Snake River
Illinois	Turbidity Sediment	Water storage, water treatment, fishing	Some reduction in turbidity Minor change in lake sedimentation
Pennsylvania	Sediment, phosphorus in surface water, nitrates in surface and groundwater	Water supply, fishing	Limited improvement
South Dakota	Nitrates in surface and groundwater, phosphorus in surface water	Water supply, swimming, boating, fishing property values	Some improvement in surface and groundwater
Vermont	Phosphorus (algae, aquatic weeds)	Swimming, boating, fishing, property values	Major reductions in algae and aquatic weeds

domestic water supplies and contributing to downstream water quality problems in the Chesapeake Bay. The project is emphasizing animal waste storage, erosion control (primarily terraces) and nutrient management. Limited localized improvement in water quality has occurred but the large land area and limited farmer participation are restricting any general water quality improvement.

In the South Dakota project, commercial fertilizer residues are degrading groundwater drinking supplies and recreational lakes. Conservation tillage and nutrient management are the primary BMPs being used to improve water quality. Preliminary evidence indicates that some improvement in water quality is likely because of RCWP.

In the Vermont project, phosphorus from animal wastes and sewage treatment plants has stimulated algae and weed growth in St Albans Bay, impairing swimming, boating and value of recreational property. This project is emphasizing storage and proper use of animal wastes. Significant improvements in water quality are anticipated as phosphorus discharges from cropland and from the sewage treatment plant are reduced.

Estimated Offsite Benefits

Estimates of the economic value of the water quality improvements for the five RCWP projects are presented in Table 2. Total estimated benefits of BMP implementation range from $0.1 million for the Conestoga Headwaters in Pennsylvania project to $4.9 million for the St. Albans Bay Vermont project. The much higher benefit estimate for St. Albans Bay stems from two major

Table 2--Estimated 50 year benefits compared with costs for five RCWP projects (Preliminary)

Item	Idaho Project	Illinois Project	Pennsylvania Project a/	South Dakota Project a/	Vermont Project
	Million Dollars b/				
Benefits					
Offsite (water quality):					
Recreation	$.4	$ + c/	+	>1.4	3.9
Water Storage	0	0	NA d/	NA	NA
Property Values	NA	NA	NA	+	1.0
Water Conveyance	.2	0	NA	NA	NA
Water Treatment	NA	.2	+	+	NA
Other	.2	NA	NA	NA	+
Total Offsite	.8	.2	0	>1.4	4.9
Onsite Benefits:					
Soil Productivity	.8	0	.1	+	NA
Reduced Farm Costs	NA	NA	NA	NA	2.0
Total Benefits	1.6	.2	.1	>1.4	6.9
Costs					
Government e/	3.4	1.6	1.0	1.4	3.9 f/
Private	3.3	.3	.3	0	NA
Total Costs	6.7	1.9	1.3	1.4	3.9
Benefit/Cost Ratios	.2	.1	.1	>1.0	1.8

a/ The economic evaluations of the Pennsylvania and South Dakota projects were started a year later and were funded at significantly lower levels than the economic evaluations of the other projects.

b/ Adjusted to a 1980 base and discounted to current value at 7.875 percent rate.

c/ Positive benefits accrue but total value is less than $50,000.

d/ Not applicable.

e/ Includes cost share payments, technical assistance, and information and education costs.

f/ Includes costs of phosphorus wastewater treatment for the City of St. Albans.

factors--a greater marginal improvement in water quality and a greater number of people affected by the improvement. The importance of these factors can be seen better by examining how total benefits were estimated.

In Idaho, sediment in irrigation return flows and in Rock Creek will be greatly reduced. This will generate $0.4 million in benefits to recreational fishing and will reduce ditch cleaning cost by an estimated $0.2 million. However, this improvement in Rock Creek will minimally affect the quality of water downstream in the Snake River. Because of the hydrologic features of the Snake River, sediment from streambanks and the river bottom would be picked up, largely offsetting any savings from reductions in sediment entering from Rock Creek. Thus, water storage or power generation benefits appear negligible. Total estimated water quality benefits over 50 years are $0.6 million. In addition, the crop residue cover from use of conservation tillage is projected to improve upland game habitat, with a hunting benefit estimated at just over $0.2 million. Total offsite benefits of RCWP in Idaho would be $0.8 million.

In the Illinois Project, sediment entering the lake will be reduced, in turn, reducing the turbidity in the lake. Costs of water treatment to remove sediment will be lowered by some $0.2 million. Also, recreational fishing will marginally improve but, because of limitations on access and on boat size, only some $24,000 in benefits will be generated. Water storage benefits appear negligible because much of the sediment will remain in suspension and pass over the dam, and because the lake's capacity is large relative to future demand. Thus, total offsite benefits of $0.2 million appear likely over a 50-year period.

For the project in Pennsylvania, the limited nature of BMP implementation over a wide area will result in minimal improvement in water quality. Localized improvements in groundwater will result in small benefits to households from improvement in water wells. In addition, minor improvements in surface water quality are expected to occur. Since the potential for increased recreational use of the Conestoga River is limited, recreational benefits are expected to be positive but quite small.

In South Dakota offsite benefits are projected to be substantial. The drainage basin includes several popular recreational lakes that have been degraded by agricultural nonpoint source pollution. If recreational use of the lake increased by 4 percent due to water quality improvement, recreational benefits would exceed $1.4 million. There is a significant number of seasonal homes located adjacent to the lakes. The value of these properties is expected to increase in conjunction with the improvement in water quality. The magnitude of this increase has not been estimated. The groundwater aquifer in the South Dakota project area serves as a source of potable water for local residents. Positive benefits are expected to occur with water quality improvement.

In the Vermont Project, greatly reduced phosphorus loadings from RCWP and better sewage treatment will improve the water quality in St. Albans Bay over time, to near that in the larger Lake Champlain. This will produce swimming and other recreational benefits of nearly $4 million, and will increase recreational property values by over $1 million. Costs of weed treatment removal will be reduced by $27,000. Thus, the total offsite benefits over 50 years are estimated at nearly $5 million.

Onsite Benefits

In four of the five projects, RCWP is generating some onsite economic benefits from preserving soil productivity or from reducing farmers' operational costs, which more than offset their RCWP installation costs.

In Idaho, planned implementation of conservation tillage and other practices that help keep soil in place on the fields will reduce long-term soil productivity loss and generate benefits estimated at $0.8 million (Table 2). In this case, these productivity benefits are as great as the offsite benefits.

In Pennsylvania, heavy manure applicationn are largely offsetting soil erosion. In the Illinois project, because soils are deep and fertile, long-term productivity benefits are negligible.

In the Vermont project, the installation of improved animal waste storage facilities reduces manure handling and fertilizer costs over time by more than the farmers' initial share of putting in the systems. This negative cost of over $2 million can be considered an onsite private benefit. Note that it is about 40 percent as large as the public benefits.

Costs

Each project has two cost components: government costs and private cost (Table 2). Government costs range from $1.0 million for the Pennsylvania project to $3.4 million for the Idaho project. This cost includes government cost-share payment, technical assistance, information and education expenditures, and local administrative costs.

Private costs are the net costs before taxes that the farmer incurs from paying his share of the BMP installation, plus the net change in operating costs. Notice that the private costs in the Idaho project are very high, nearly equal to government costs. 1/ By comparison, in the Vermont Project net private costs are zero because the reduction in operating costs exceeds the installation cost, so the negative cost gets listed as a private benefit.

Benefits Versus Costs

How do the estimated benefits in the three comprehensive monitoring and evaluation projects compare with the costs of implementing the projects to generate the benefits? The answer to this question is affected by which benefits we compare with which costs. First, let's compare total benefits, including both public and private, with total costs, again including both government (or public) and private. The Vermont project with a benefit/cost ratio of 1.8 to one and the South Dakota project with a benefit/cost ratio that exceeds one are the only projects of the five that are economically justified (Table 2). For these projects total economic benefits will likely exceed costs. In the Idaho, Illinois, and Pennsylvania projects, total economic benefits are projected to be only one-fourth or less as large as total costs.

1/ It appears the farmers in the Idaho project are able to shift much of this cost back on the government through investment tax credit and depreciation.

If we say that these projects were undertaken to improve water quality and produce offsite benefits, and we are interested in how much we are getting for the government buck, we would compare offsite benefits against government costs. When we do this, the benefit to cost ratio for the Idaho project drops to 0.2 and the ratio for Pennsylvania approaches zero, while the others remain the same.

Implications

The results from the individual economic evaluations of the five comprehensive monitoring and evaluation RCWP projects can be generalized to provide guidance in planning future projects and programs designed to control agricultural nonpoint source pollution. For convenience we group the implications from the economic evaluations into four categories: economic impairment, costs and effectiveness of BMPs, incentives to participate, and benefits versus costs.

Before drawing some implications from these evaluations, several limitations need to be pointed out. First, these evaluations are preliminary. Second, the RCWP projects were not selected on the basis of anticipated benefit/cost ratios, but rather to experiment and try out the program in different problem and geographical settings. Although the Idaho, Illinois, Pennsylvania, and some other RCWP projects may have low benefit/cost ratios, the information they provide will be valuable for guiding future programs. A third limitation is that the RCWP projects are not representative statistically of possible agricultural NPS projects. Thus the results should not be used to generalize about the economic efficiency of a future program.

Economic Impairment

The importance of pre-project assessment of the economic impairment and of the potential benefits from improving water quality is demonstrated by the economic evaluation of RCWP. Potential benefits can vary considerably among areas and should not be measured only by examining levels of pollution. Each of the RCWP projects were targeted to areas with highly polluted water. However, the estimated offsite water quality benefits for pollution control ranged from under $250,000 for the Illinois project to nearly $5 million for the Vermont project (table 2). 2/

A key factor affecting potential offsite benefits appears to be the level of demand for the water resource, particularly with regard to recreational opportunities. Potential benefits depend on the number of activities impacted, and economic importance of these activities. In Vermont and South Dakota, the likely recreational benefits are sizable, while in the other three projects they are relatively small. In addition to increased recreational opportunities, other offsite impacts associated with the various RCWP projects include: property values, sedimentation of water storage facilities, power generation costs, water supply and treatment costs, and ditch cleaning costs.

The importance of measuring the contribution of agricultural nonpoint source pollution to water quality and determining an economic impairment before

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2/ The estimate of negligible water quality benefits for the Pennsylvania project reflects the failure to implement a sufficient number of the appropriate BMPs. If water quality were improved in the project area, the magnitude of the offsite benefits would be significant.

project implementation is illustrated in the case of the Illinois RCWP project. When the project was initiated, the loss of storage capacity from deposition of sediment in the Highland Silver Lake was identified as the principal impairment. Reductions in erosion in the watershed would reduce sediment delivery to Highland Silver Lake, the primary source of drinking water for the City of Highland. Substantial offsite benefits were envisioned through elimination of the need for dredging the lake or finding an alternative source of water. However, subsequent analysis of the Lake's siltation revealed that much of the sediment was not settling out and remaining on the lake bottom but rather was either staying in suspension or being resuspended and passing through the lake. Also the reservoir capacity was large relative to future demand. Thus, there was no significant problem in terms of lost water storage capacity in the lake and the primary benefit identified for the project had negligible economic value.

A similar situation occurred in the Rock Creek Project in Idaho. Reduced siltation of power-generation reservoirs behind dams on the Snake River was identified as a significant potential benefit from the Rock Creek project. However, subsequent evaluation revealed that reductions in erosion in the Rock Creek watershed were unlikely to significantly affect the water storage facilities 100 miles downstream. Although measurable reductions in sediment delivery to the Snake River occur, the Snake River itself will tend to pick up replacement sediment from streambanks and the river bottom.

In addition to offsite water quality benefits the Idaho and Pennsylvania projects generate onsite soil productivity benefits. A policy question is whether offsite and productivity benefits should receive the same or differing priorities in allocating resources. A similar concern exists with regards to wind erosion. Although none of the RCWP projects experienced wind erosion, in some regions offsite wind erosion damages can be significant. Whether or not productivity and wind erosion benefits are included with water quality benefits could make a major difference in the economic feasibility of a project.

Costs and Effectiveness of BMPs

The costs and effectiveness of BMPs (best management practices) to improve water quality are dependent upon proximity to watercourse, surface slope, soil type, timing of precipitation, other BMPs in place, agronomic practices in the area, and the water quality problem being addressed.

In general BMPs were effective in improving water quality in the projects. However, the relative effectiveness varied considerably from one project to another. For example, in Vermont animal waste storage reduced the quantity of nutrients reaching the watercourse by permitting more timely application to meet crop needs and avoid runoff. A different result occurred in Pennsylvania where Lancaster County, the site of the RCWP project, has the highest concentration of animals per acre of any county in the United States. Installation of animal waste storage facilities conserves nutrients, resulting in greater amounts of high nutrient manure being applied at a given time than would otherwise occur. However, the increased levels of nutrients resulting from animal waste storages surpasses the amount of nutrients that the crops can use. These excess nutrients appear to be moving downward into the groundwater and subsequently to the Conestoga River in baseflow. Thus, delivery of nutrients to the watercourse actually increases or remains constant with the installation of the BMP.

A BMP preferable to long term storage in the Pennsylvania Project might be short-term manure storage and an application mode which increases nitrogen volatilization. Other alternatives that could increase the effectiveness of the project include removal of the manure from the farm to other areas which can use the nutrients, and institution of disincentives for farmers in the project area to have such high concentrations of animals on their farm.

The relative cost effectiveness of individual BMPs is also dependent upon the type and location of the water resource to be protected. Soil conservation practices such as terraces and conservation tillage are generally effective at reducing surface losses of pollutants. If the concern is protection of a groundwater resource, the effectiveness of these practices is greatly reduced. The advantage of soil conservation practices is that they reduce the velocity of the water as it flows off the land thereby reducing the amount of soil and attached nutrients that can be carried with the water. Also, since the rate of flow is reduced, more water and nutrients infiltrate into the ground. Thus, in attempting to protect a groundwater resource as in the Pennsylvania and South Dakota projects, soil conservation practices may actually increase the discharge of nutrients and pesticides to the groundwater. Modeling results from the Pennsylvania project show that some BMPs, such as fertilizer management, can reduce loadings to both surface and groundwater (Crowder and Young). Heavy reliance on runoff-reducing practices such as terraces and conservation tillage can have negative effects on groundwater quality, thereby, solving surface water problems by impairing groundwater.

The selection and placement of BMPs also impacts the relative costs and effectiveness of a water quality program. With water quality, the concern is reducing pollutants delivered to the waterbody. A given reduction in delivery of pollutants can be attained by intensively treating a small area which has high discharge or extensively treating a large area. For example, in the Idaho RCWP project, initial emphasis was given to fairly costly structural BMPs which trapped sediment at the end of the field or improved irrigation. Alternative BMPs were examined to determine more cost effective ways of reducing sediment delivery. One such BMP was conservation tillage (including no-till), which if it could be implemented throughout the watershed, would not only reduce sediment delivery below that projected for the original set of BMPs, but it would also reduce costs. In addition, conservation tillage would help retain soil in place on the field, rather than trapping it at the bottom, and thus producing a soil productivity benefit.

Incentives to Participate

A voluntary water quality program such as RCWP cannot succeed without providing the appropriate participation incentives to farmers contributing to the problem. RCWP provides cost sharing up to 75 percent of the cost of installing BMPs with a maximum of $50,000 per farm. In addition, RCWP funds educational programs to promote and demonstrate the advantages of BMPs to farmers. The economic evaluation of RCWP indicated several opportunities for farmers to gain from participation in the program.

The primary BMP in the St. Albans Bay project in Vermont is animal waste storage. In the case of animal waste storage structures, nutrients which can be utilized for crop production are conserved, resulting in reductions in purchased fertilizer. The economic evaluation of the animal waste storage BMP for the St. Albans Bay area revealed that a farmer could recapture most of the costs of installing an animal waste storage structure over a 20-year planning horizon due to the savings in fertilizer purchases. Thus, farmers may be willing to adopt manure storage structures at a lower cost share rate than the present 75 percent that is available in the project. This would result in substantial savings to the government with minimal reduction in the overall level of implementation of the animal waste storage BMP.

An opposite phenomena occurred with manure storage and handling in the Pennsylvania project. In this instance the nutrients saved by manure storage have a low value to the farmer because he has sufficient nutrients to meet crop needs even when he uses the relatively inefficient (in terms of nutrient savings) daily spreading system. Thus, if society wants these farmers to switch to less polluting manure management systems, cost sharing or regulations will be necessary to induce participation.

As previously mentioned for the Idaho project, conservation tillage was found to be a cost-effective BMP for preventing erosion. Conservation tillage provides two benefits to the farmer which will encourage participation in the project. First, net income is projected to be higher with conservation tillage than for conventional tillage practices. Second, adoption of conservation tillage provides long-run productivity benefits. While a farmer may not place a high present value on these benefits, they are worth something to him.

An additional incentive that must be kept in mind with structural BMPs, such as terraces or animal waste storage structures, is the income tax deductions that are available for this type of investment. Much of the farmer's costs for structural BMPs can be deducted from income taxes which provides an additional incentive to install the BMPs.

The payback period for nutrient savings from manure storage, soil productivity, and income tax writeoffs may be too long for a farmer's planning horizon. Low-interest loans may be sufficient incentive for farmers to adopt practices that have long-term paybacks.

Farmers can also benefit from localized improvements in water quality. In Pennsylvania installation of BMPs created localized improvements in groundwater. Frequently the groundwater resources that were improved were the source of drinking water for the farm. Farmers are more likely to participate if the benefits accrue directly to them such as reduced health risks associated with drinking contaminated water.

Benefits Versus Costs

Comparison of the benefits and costs of the five RCWP projects indicates that only two of the projects have or will likely have benefit-cost ratios that exceed one. Nevertheless several implications can be derived from the comparison.

Is the measure of the success of a RCWP project only offsite water quality improvements or should onsite long-run productivity benefits be included? The mix of projects to be funded will be radically different if either offsite or productivity benefits are considered in isolation. If the Idaho project had been originally designed to emphasize conservation tillage rather than the mix of structural practices selected, the benefit-cost ratio could have exceeded one, even though sediment delivery and offsite benefits would be similar. The longrun productivity benefits and cost savings associated with conservation tillage make the difference.

The benefit-cost ratio is influenced by the size of the project. For example, as the Conestoga Headwaters project in Pennsylvania has been implemented the B/C ratio is close to zero. Even if the project were implemented as planned the ratio would remain low. However, if the project area were expanded and a high level of participation were achieved, substantial offsite benefits could be generated. A larger project would protect the water supply for the City of Lancaster and would influence water quality in Chesapeake Bay, thus potentially generating large benefits.

Conclusions

RCWP has provided a unique opportunity to study the economics of agricultural nonpoint source pollution control. Evaluation of the program highlighted four factors that will improve the economic efficiency of future agricultural nonpoint source pollution programs.

Individual projects should be targeted towards water bodies that have water quality problems that are causing economic damages. Existence of a polluted water body is an insufficient reason for targeting an area for water quality improvement via agricultural nonpoint source pollution control. Elimination or reduction of the water quality impairment must have a measurable economic value.

The relative costs and effectiveness of the practices selected to reduce the delivery of pollutants can impact program costs substantially. In certain instances intensive treatment of critical sources of pollution is cost effective, while in other areas extensive treatment of a watershed with low cost BMPs is preferable. In addition the relative effectiveness and cost effectiveness of individual BMPs can vary dramatically from one location to the next. The relative cost effectiveness of individual BMPs is also dependent upon the type and location of the water resource to be protected. A BMP, such as a terrace, may be quite effective in reducing surface losses of pollutants, but be ineffective in protecting ground water resources.

Control of agricultural nonpoint source pollution cannot be accomplished without adequate participation by farmers who are contributing to the water quality problem. Cost sharing and the use of low cost or no cost BMPs are two methods that were successful for RCWP. Private benefits can accrue to farmers through the use of BMPs. Erosion reduction can maintain the productivity of soil over time and can reduce annual losses of nutrients from fields. Nutrient management and manure storage also reduce fertilizer costs.

Finally, even if a project is successful in encouraging farmers to participate using cost effective BMPs to improve water quality at a site that has economic value, the project may not meet a benefit cost criteria. Only two of the five RCWP projects evaluated had benefit cost ratios that exceeded one.

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