Water Quality

First Draft
September, 1979

1979

BEST MANAGEMENT PRACTICES: ECONOMIC ISSUES AND WATER QUALITY IMPLICATIONS

GEORGE L. CASLER
DEPARTMENT OF AGRICULTURAL ECONOMICS
CORNELL UNIVERSITY

Modified version of remarks made at a Symposium on Agriculture + Water Quality Improvement: What are the Implementation Cost + Policy Issues? at the AAEA Meeting in Pullman, WA, July 29 - Aug 1, 1979

BEST MANAGEMENT PRACTICES:
ECONOMIC ISSUES AND WATER QUALITY IMPLICATIONS

I am interested in solving or at least alleviating the problems of non-point water pollution from agricultural production. It will take a combination of economics, politics, bureaucracy, and physical and biological information to accomplish the job. Many of our rather elegant economic ideas and models are not likely to have great impact on the actions that are taken to reduce non-point pollution. Perhaps the best that economists can do is to help ensure that large amounts of money are not spent on programs that do little or nothing to alleviate agricultural sources of non-point pollution.

My comments are limited to non-irrigated agriculture east of the 100th meridian which runs about through Lincoln, Nebraska. You can judge whether they have any relevance to irrigated agriculture or to non-irrigated agriculture west of the 100th meridian.

I have several concerns about the efforts of the United States to deal with non-point pollution from agriculture:

1. Are the water quality problems well defined?
2. Do we know how to correct them?
3. Or are we really just working on erosion control?

This paper is a somewhat modified version of remarks made at a symposium on Agriculture and Water Quality Improvement: What are the Implementation Costs and Policy Issues? at the AAEA meeting in Pullman, Washington, July 29-August 1, 1979. At the time this paper was completed, the author was a visiting professor of economics at Colorado State University.

I believe that it is time for a mid-course or perhaps a mid-stream correction in what we are doing. You may believe that it is rather late in the game for a major mid-stream correction since we are finally to the point where the EPA is in gear with 208 planning, most states have prepared non-point control plans, and Congress is close to appropriating cost-sharing money, although they didn't quite make it last year.

ECONOMIC ISSUES

My work in the area of non-point pollution from agriculture goes back about 10 years. My first paper on the subject was presented at the NAEC meeting in Amherst, Massachusetts, in 1959. Most of my work in the area has been part of interdisciplinary projects with agronomists, engineers, aquatic biologists, and sociologists. You will find that I talk as much about the physical and biological issues as I do about economic issues. I am going to paint with a rather broad brush.

Let me summarize some of what I believe we know and don't know, starting with the cost-effectiveness of BMP's. First, I believe we should throw out or alter the phrase "best management practices". It implies that someone, somewhere, knows what is the best practice to control non-point pollution. In most situations that is probably not true. In one recent session (perhaps a review team for one of our research projects) we decided to change BMP's to AMP's. I don't remember whether it meant "alternative" or "acceptable" management practices but it seems to me that the latter would be more descriptive and useful than "best".

Soil Erosion and Sedimentation

A number of studies, one of the first by Jacobs around 10 years ago, seem to have established that reduced tillage, either conservation tillage or no-til, are cost effective for erosion control on many crops and soils. In cases where adverse yield effects are nil or small, the cost reductions for reduced tillage result in improved farm incomes. Therefore, it should be relatively easy to induce farmers to adopt such practices. I also understand that on a number of soils and crops reduced tillage methods are unsatisfactory. In particular, conservation tillage or no-til are not acceptable practices on cotton. These practices do not work well on some of the heavier, wetter, and colder soils used to grow corn and soybeans. Chisel plowing has been rapidly adopted in many corn and soybean areas, although there is some question of whether the result really qualifies as conservation tillage.

On many of the steeper slopes, reduced tillage is not sufficient to reduce erosion to "acceptable" levels. Either structural practices such as terraces or rotations with more hay are needed. In most cases, these practices will reduce net farm incomes, at least in the short run. It will be difficult to get farmers to adopt such practices without substantial cost-sharing or strict enforcement of regulations.

One of my great concerns is that the profitability of erosion control measures and of structural practices in particular depends on both the short and long run yield effects of the practices. I believe that our knowledge of these yield effects is woefully inadequate. It was pointed out in an earlier session today that someone in the USDA has come up with long run yield effects of soil conservation practices for a number of crops in something like 22 watersheds. He must either be more diligent than I in searching the literature or more creative in crunching numbers to have anything on which to base those yield effects. Nevertheless, the yield effects of soil conservation need to be established in order to convince farmers of the benefits to themselves from erosion control.

Nutrients and Pesticides

The real issues with respect to nutrients and pesticides are in the physical and water quality areas. Therefore, I am not going to make any statements at this point about the cost-effectiveness of BMP's for the control of such substances.

WATER QUALITY IMPLICATIONS

The most recent research projects in which I have been involved are interdisciplinary primarily with soil and water and systems analysis people in agricultural engineering. They have been working on physical models to try to get a handle on what happens to substances other than sediment that might have water quality impacts. We have not really pushed the analysis as far as the water quality impacts but are tying to understand the movement of nutrients and perhaps pesticides at the field level.

Sediment

Before I discuss that, I want to make some comments about sediment. Assuming that the universal soil loss equation (USLE) gives reasonably correct results, and there is some question about that, we know quite a bit about controlling erosion. There is a tendency to believe that reduced erosion on farmland leads to a proportional reduction in sediment carried by streams and rivers and sediment deposited in lakes and reservoirs. I would like to raise the question, "Where is the evidence?" I really have not seen it and don't believe it exists. First of all, we have the matter of delivery ratios. I think we do know that delivery ratios vary by distance from the stream and probably by elevation above the stream. Much of the eroded soil is redeposited before it reaches the stream. A substantial portion of this redeposition is within the field where the original erosion occurred. I have not seen a watershed model that operationalizes this concept. Also, do delivery ratios change as erosion is reduced? And in which direction? In addition, particle size and enrichment ratios for some nutrients such as phosphorus appear to be a function of amount of erosion, but the quantitative relationships are not well defined. The implications of this for water quality will be discussed later. Another problem, of course, is stream bank erosion and the sediment carrying capacity of streams. Some hydrologists believe that in many watersheds, reduction in soil erosion on the land will actually have little impact on the amount of sediment carried by the stream. In total, I believe that we will be forced to find much of the benefit from erosion control somewhere other than in the stream which drains the farmland.

Nutrients

There is a tendency to believe that reducing erosion will solve or at least markedly reduce the problem of excess nutrients in surface water. This may not be true and probably is not true particularly for the important forms of nitrogen and phosphorus. Nitrate nitrogen, the form of nitrogen most people are concerned about, is more likely to be related to cropping patterns and levels of nitrogen fertilization than to soil erosion. Erosion control is not likely to reduce the problem of nitrate nitrogen levels in water unless erosion control is accomplished by substituting crops which use little nitrogen fertilizer.

In the case of phosphorus, there is substantial controversy over whether soluble or total phosphorus is the important substance to be controlled. One of the groups that I worked with several years ago quite clearly established that soluble phosphorus, not total phosphorus, is the key to controlling excessive growth of algae [Porter, 1975]. However, it seems quite clear that those who agree with us are in the minority. Most people who claim to be knowledgeable about the situation appear to believe that control of total phosphorus will effectively control excessive algae growth and that erosion control will control a major portion of the phosphorus in question. I believe that erosion control will be quite effective in controlling total phosphorus although if the phosphorus enrichment ratio varies inversely with the quantity of eroded soil, the control of total phosphorus will not be proportional to erosion control. It is quite possible that some erosion control practices, such as no-til, which leaves much residue on the surface will lead to increases rather than decreases in soluble phosphorus runoff [Colette]. Erosion control in general may not control soluble phosphorus very well. If soluble phosphorus control is a major key to improved water quality, I am afraid that erosion control will give disappointing results.

Pesticides

Erosion control is not likely to solve many water quality problems related to pesticides. While erosion control will reduce the amounts of pesticides strongly adsorbed to soil that get into surface waters, the key to pesticide problems of water quality is likely to be something else, such as changes in types of pesticides or biological controls.

Modeling Results

Before I show you some data from nutrient modeling efforts at Cornell I would like to make this statement: Despite literally millions of dollars spent by EPA and other organizations on efforts to model or measure nutrient and pesticide runoff and inputs to surface and ground water, we still don't know much about it. I believe that some of the modeling efforts were a waste of money and that could have been known before the work was done. But the real problem is that the processes involved are complex and not easily measured or modelled. The available data base is probably still much smaller than that used to develop the USLE.

The data I will present results from the Cornell Nutrient Simulation (CNS) model [Haith and Loehr] developed by agricultural engineers at Cornell. Table 1 shows some estimates of changes in dissolved nutrient losses resulting from the application of several alternative soil conservation practices to one soil and cropping situation in Iowa. You should focus on the changes in nutrient losses relative to the changes in soil losses. In all cases the losses are "edge of field" losses and do not consider delivery ratios.

The major point to be made from the data in this table is that, except for the corn-alfalfa rotation, the application of soil conservation practices to continuous corn results in much smaller reductions in runoff losses of disolved nitrogen and phosphorus than the reductions in soil losses. Except for the corn-alfalfa rotation, the conservation practices increased the amount of leached nitrogen and the total amount of dissolved nitrogen leaving the field did not change. The major reason that the impact of erosion control measures is much less on dissolved nutrient runoff than on soil losses is that the impact on runoff of water is much less than the impact on soil erosion. Those who believe that control of dissolved nutrients rather than control of total nutrients is a major key to improved water quality are likely to question whether erosion control will cure our water quality problems.

I must admit that I don't have a great deal of faith in the CNS model. Tests of it against measured plot data have given less than spectacular results. However, I have not seen other workable nutrient models that do as well. The developers of the model have stated that it is as good as the USLE. At this point, I cannot resist a comment about the USLE. Many economists, including me, have used the USLE as part of our economic models. Yet I doubt that any of us have intensively studied the development of the equation. If any of us had submitted an article to the AJAE describing the development of the USLE as a production function, the reviewers would probably have laughed us off the pages. I believe that the factors used for some of the conservation practices are particularly weak. It is rather sobering to think of the numerous economic studies of pollution control that are largely based on the USLE and that probably no economist has ever tried to fit a production function (with soil loss as the dependent variable) to the data base used to develop the equation. I believe it would be useful for an economist to fit such a production function. Perhaps it would be useful for us to expend perhaps 5 percent of the effort that the profession has expended on fertilizer production functions to estimate an erosion function.

CRITICAL NEEDS

I would like to sum up with what I believe are some of the critical research needs in terms of solving or alleviating the non-point pollution problems of agriculture.

We need better data on the long-run impact of erosion control on crop yields. I have pointed out to many people that erosion does not appear to be the overriding factor in yields. For example, U.S. corn yields per acre more than doubled (40 bushels to over 100 bushels) from 1948 to the mid-1970's. During this period, according to the USLE and other evidence, billions of tons of soil erosion occurred. Of course, the crucial question is what corn yields would be today if there had been less erosion in the last 30 years. If we had good data we might be able to alter my coffee room quote from Paul Barkley who says that, "soil conservation just doesn't pay for farmers."

A second critical question is whether conservation tillage and no-til really work: Is the reduction in erosion as great as the USLE says it is? And is the chisel plowing that many farmers are doing really conservation tillage? Farmers appear to be chisel plowing because it reduces their costs but in many cases are leaving less residue on the surface than necessary to qualify as conservation tillage. They appear to be substituting chisel plowing for other conservation practices. They are aided and abetted by economists, agronomists, SCS technicians, etc., who use the USLE and show substantial reductions in erosion. But is the real erosion consistent with our calculations?

A related need is for more information on the yield responses to no-til and conservation tillage. There is some good data for some crops and soil types but more is needed. We probably need a combination of plot data and good records of farmer experience with these practices.

The management requirements of these practices, particularly on some soil types, appear to be greater than with conventional tillage. If we are to rely on reduced tillage for much of our erosion control, intensive extension efforts may be needed.

We need to know more about movement of nutrients from land to surface water and methods of control. The nutrient loss data I presented was edge of field--really edge of plot because it was based on two acre fields. Very little seems to be known about delivery ratios for nutrients. I am not hopeful that our level of knowledge in this area will increase markedly in the near future.

There is also a critical need for more quantification of the benefits of improved water quality as a result of less sediment, nutrients, etc. Relatively little work has been done in this area.

At the start of my presentation I suggested that perhaps we need a mid-stream correction in our work on control of non-point sources of pollution from agriculture. The bottom line of my comments is: Is the program we are about to embark upon--the 208 program and the cost-sharing likely to accompany it--likely to lead to significant improvements in water quality? Or should we admit that what we are doing is trying to control erosion and hope that there will be some water quality benefits to justify the costs that are not recouped by the benefits of erosion control?

TABLE 1: Effects of Selected SWCPs on Average Annual Soil, Runoff, and Nutrient Losses, Tama Silty Clay Loam, Iowa (estimated with Cornell Nutrient Simulation Model). Continuous corn except for the Corn-Alfalfa 50-50 rotation.

Practice	Soil Loss	Runoff	Dissolved Phosphorus Runoff	Dissolved Nitrogen Runoff	Nitrogen Leached	Nitrogen Runoff + Leached
	---------------------Percentage Change----------------------					kg/ha
Conventional[1/]	---	---	---	---	---	75
Contour	-55	-15	-20	-25	+10	76
Terrace	-95	-30	-30	-30	+10	76
C-A Rotation	-60	-55	-55	-75	-50	34
Conservation Tillage 2/	-70	-30	-35	-30	+10	76

1/ Straight row, moldboard plow.

2/ Chisel plow, lots of residue left on surface.

REFERENCES

Collette, W. A., "A Review of Relationships between Agricultural Practices and Nitrates and Phosphates in Water Supplies," CARD Working Paper, Iowa State University, December, 1973.

Haith, D. A. and R. C. Loehr, eds., Effectiveness of Soil and Water Conservation Practices for Pollution Control, New York State College Of Agriculture and Life Sciences, Cornell University. Report to USEPA, Athens, Georgia.

Jacobs, J. J. and J. F. Timmons, "An Economic Analysis of Agricultural Land Use Practices to Control Water Quality," AJAE, 56:796-798.

Porter, K. S., ed., Nitrogen and Phosphorus: Food Production, Waste, and the Environment, Ann Arbor Science, Ann Arbor, Michigan, 1975.