SOIL AND WATER QUALITY: ISSUES FOR THE FARM BILL

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Introduction

Nonpoint Source Pollution (NPS) from agriculture has been recognized as the major problem affecting water quality across the nation for some time. While NPS is not the acute problem that industrial point sources or toxic waste sites can be, NPS is problematic because it is so pervasive. It is the result of our daily actions, our daily management of the land around us. While the environmental impacts of individual actions may hardly be noticeable, the cumulative effects may be great, particularly with their persistence over time. Most of us in agriculture have learned these principles in relation to soil erosion over the past 50 years. Over the past few decades we have also come to realize that our increased use of nutrients, pesticides, and other inputs have resulted in similar cumulative impacts on the environment (e.g., Hallberg 1989 a, b).

Improving the environmental performance of agriculture is an issue of national urgency and must be a primary consideration in the continuing evolution of farm programs and policies. Over time, the complexity of farming and of farm policy has been part of the problem, as well as part of the solution. Through the past half century conservation programs have been intertwined with income support programs and (in retrospect) too narrowly focused on one concern, soil erosion. National policy of the 1960s and 70s pushed agriculture to greater intensity and production, with little realization of the effects on soil and water quality. National programs and policies have had continual problems dealing with the diversity of agriculture and the diffuse nature of an 'industry' such as farming. But I do not intend this paper as a policy treatise; these issues are well covered in other papers in this volume. I hope to outline some key technical issues that must be considered to improve the design of policy and program directions.

In late 1993, the National Research Council's Board on Agriculture issued the report: Soil and Water Quality: An Agenda For Agriculture. It has been cited and praised as presenting a comprehensive view and a workable, systems approach to improve the environmental performance of agriculture, in a framework that can improve the economic performance of most farming systems, as well. This report was awarded the 1995 Merit Award from the Soil and Water Conservation Society of America. This report was prepared by the Committee on Long-Range Soil and Water Conservation (Table 1); in this discussion, I will briefly review some pertinent findings of our committee. These are principally technical approaches to improve the management and protection of agricultural-environmental systems. This is merely a brief review, from my perspective, of a very comprehensive report. The reader should refer to the report for a more complete treatment and for technical details.

Soil and Water Quality

The Soil and Water Quality report defines four broad approaches that hold substantial promise for preventing soil degradation and water pollution while sustaining profitable agricultural production. Programs should seek to: (1) conserve and enhance soil quality as a fundamental first step to environmental improvement; (2) increase the efficiency of input use (e.g., nutrients, pesticides, and irrigation water) in farming systems; (3) increase the resistance of farming systems to erosion and runoff; and (4) make greater use and integration of field and landscape buffer zones.

These four approaches are interrelated. Emphasis on one, to the exclusion of the others, may simply exacerbate one environmental problem while solving another. To avoid such tradeoffs, and to maximize their success, these four approaches must be applied in a systems framework. Reducing runoff, for example, without improving nutrient management may reduce the mass of nitrogen reaching surface water but increase the amount of nitrate leaching to groundwater. The balance between approaches may necessarily change over time and from one region to another to best address local conditions. For example, in some cases, shifting emphasis to creating buffer zones, as the cost of refining input management increases, may be the least expensive way for producers and taxpayers to prevent pollution. Ultimately, the decision to emphasize one approach over another is, at least implicitly, a political and social judgment on the importance of protecting particular soils or water bodies.

Enhancing Soil Quality

The report concludes that protecting soil quality, like protecting air and water quality, should be a fundamental goal of national environmental policy. The Clean Air Act and the Clean Water Act give national recognition to the fundamental importance of air and water resources. Soil resources are equally important components of environmental quality, and national policies to protect soil resources should be based on the fundamental functions that soils perform in natural and agroecosystems.

Soils are living, dynamic systems that are the interface between agriculture and the environment; they are the underpinning of the agricultural ecosystem. The Soil Science Society of America defines soil quality as: "The capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. (SSSA, 1995)" The quality of a soil depends on attributes such as the soil's texture, depth, permeability, biological activity, capacity to store water and nutrients, and the amount of organic matter contained in the soil. Various scientific groups are working on measurable criteria to define and monitor soil quality (e.g., Warkentin, 1995; Papendick and Parr, 1992). High-quality soils promote crop growth and make farming systems more productive. High-quality soils prevent water pollution by resisting erosion, absorbing and partitioning rainfall, and degrading or immobilizing agricultural chemicals, wastes, or other potential pollutants. The quality of some U.S. soils is degenerating because of erosion, compaction, salinization, loss of biological activity, and other factors. The full extent of soil degradation in the U.S. is not clearly known, but current economic estimates of damage from erosion alone understate the true extent and full cost of soil degradation.

Past programs and policies to protect soil resources have been too narrowly focused on controlling erosion and conserving soil productivity. Erosion is not the only, and in some cases, not the most important threat to soil quality. Salinization and compaction are important and often irreversible processes of soil degradation. More important, erosion, salinization, compaction, acidification, and loss of biological activity interact to accelerate soil degradation. Approaches that address all processes of soil degradation are needed.

Similarly, soil productivity is not the only, and often not the most important reason to protect soil resources. Soil and water quality are inherently linked. Preventing water pollution by nutrients, pesticides, salts, sediment, or other pollutants will be difficult and more expensive if soil degradation is not controlled. Protecting soil quality alone, however, will not prevent water pollution unless other elements of the farming system are addressed.

Efficient Use Of Inputs

Agricultural production inevitably generates a certain mass of residual products including nutrients, sediments, pesticides, salts, and trace elements that can, and often do, become pollutants. The emphasis of traditional conservation programs has been to minimize the discharge of pollutants from the farming system by reducing erosion and runoff. Preventing surface water and groundwater pollution by reducing the sources of contamination should be the goal of national policies.

Treatment of drinking water to remove nitrate and pesticides is expensive and in some cases ineffective. The disruption of agricultural and aquatic ecosystems caused by excessive nutrients, pesticides, sediments, salts, and trace elements may be difficult or impossible to reverse at a reasonable cost or in a reasonable length of time. Preventing pollution by improving and changing farming practices, rather than treating problems after they have occurred, should be the primary approach to solving water pollution problems caused by farming practices.

Increasing the efficiency of nutrient, pesticide, and irrigation water use reduces the total residual mass of nitrogen, phosphorus, pesticides, salts, and trace elements that can become pollutants. In many cases, efficiency can be achieved by using fewer nutrients or pesticides, or both, or less irrigation water to produce the same yield; in other cases, efficiency can be achieved by increasing the yield. Many technologies and management methods are already available that can dramatically increase the efficiency of nutrient, pesticide, and irrigation water use, but they need to be more widely implemented.

The goal of such pollution prevention is source reduction, to reduce the total mass of nutrients, pesticides, salts, and trace elements that are lost to the environment. It is clear that the environmental losses of many agricultural pollutants are proportional to their loading to the soil system; e.g., the loss of phosphorus (P) in runoff is related to the loading/concentration in the soil surface and the loss of nitrate in leachate to groundwater is related to the N loading to the soil (NRC, 1993; Baker and Laflen, 1983; Hallberg, 1987; Sharpley et al., 1993). Solutions that reduce loadings of one pollutant by increasing the loadings of a different pollutant or that reduce loadings to surface water by increasing loadings to groundwater are not acceptable or effective in the long term. Source reduction eliminates or minimizes these tradeoffs. A farming systems approach is requisite to comprehensive implementation. In many cases, the cost of achieving greater efficiency in input use is more than offset by reduced costs of production. In those farming systems where these economic incentives are significant, substantial and rapid progress toward preventing water quality problems may be possible.

Increasing Resistance To Erosion And Runoff

There are a great diversity of conservation tillage and residue management systems that are well-understood and provide effective means of reducing erosion and runoff. Many of these systems result in dramatic decreases in erosion and runoff from farming systems and from agricultural watersheds. The major opportunity to improve the effectiveness of these systems is to increase their use on lands that are most vulnerable to soil quality degradation or that most contribute to water pollution. In some regions the applicability of these systems may be limited, however, because of unfavorable physical or economic factors.

Unfortunately, much of the damage from erosion and runoff can occur during large magnitude storms that occur infrequently. Such major events often overwhelm current conservation systems and continue to cause serious, long-term damage. For example, a 38 year study in Missouri illustrates that over 60% of the erosion was caused by about 4% of storm-runoff events (Hjelmfelt and Kramer, 1988). We must incorporate this reality and identify approaches that combine residue management with changes in cropping systems and other cultural and structural practices to design farming systems that can resist damage from storm events of various duration and intensities. Part of this design must be the systematic linkage to field and landscape buffers. Various studies show that a large proportion of sediment in major streams in the humid U.S. is derived from bank and bed erosion, also. Hence, the design must include stabilization of the riparian corridor and linkage to other buffers.

Field And Landscape Buffer Zones

Field-by-field efforts to conserve soil quality, improve input use efficiency, and increase resistance to erosion and runoff will not be adequate to protect soil and water quality in regions where overland and subsurface movements of nutrients, pesticides, salts, and sediment are pervasive. Buffer zones to intercept or immobilize pollutants and reduce the amount and energy of runoff need to be created and protected to prevent soil degradation and water pollution. These buffer zones must be designed and implemented using an agricultural-ecosystem (or a watershed) framework. New and existing buffer zones must be connected across fields and farm boundaries for optimal effect. Buffer zones can include natural riparian corridor vegetation; simple, but strategically placed, grass strips; or sophisticated artificial wetlands.

Programs to protect existing riparian vegetation, whether bordering major streams or small tributaries, lakes, or wetlands, should be promoted. The creation or protection of field or landscape buffer zones, however, should augment efforts to improve farming systems. They should not be substitutes for such efforts. Such delivery reduction measures without adequate source reduction measures will not be effective in the long term.

Implementing The Agenda: Farming Systems Management

The major vehicle to implementing these elements is a farming systems management approach. Inherent in this concept, as used in the report, is an agricultural ecosystem view (e.g., landscape integration of buffer zones, input balances and management, a watershed approach). Encouraging or requiring the adoption of single-objective best-management practices is not a sufficient basis for soil and water quality programs at the farm level. Inherent links exist among the components of a farming system and the larger landscape. Adoption of a tillage system that increases soil cover to reduce erosion, for example, may require changes in the methods, timing, and amounts of nutrients and pesticides applied. Management of manure is a critical issue for improving the environmental and economic performance of farming systems. Many programs have focused on development of manure handling and storage structures to mitigate surface water impacts. But these practices must be integrated into an overall erosion and runoff control plan, and appropriate land application of manure must be fully integrated into nutrient management plans to fully realize the potential economic and environmental benefits. Programs throughout the country continue to demonstrate that integrated cropping, nutrient, and pest management approaches are cost effective means to pollution prevention, often increasing profitability (e.g., Hallberg et al., 1991; Contant et al., 1993; Anderson, 1994; Extension Service, 1993). Failure to recognize and manage these links increases the cost, slows the rate of adoption, and decreases the effectiveness of new technologies or management methods. Integrated farming system ("whole" farm) plans should become the focus of soil and water quality programs. It is also imperative that we incorporate into implementation plans better programs to understand the social and economic framework of farmers and farming systems to improve the delivery of technical assistance and information and to influence producers' decisions.

The report concludes that the development and implementation of approved integrated farming system plans should be the basis for delivery of education and technical assistance, should be the condition under which producers become eligible for financial assistance, and should be the basis for determining whether producers are complying with soil and water quality programs. In the long term, implementation of an integrated farming system plan should be required of producers, regardless of their participation in federal farm programs, in regions where soil degradation and water pollution caused by farming practices are severe.

Keeping and using records of production practices, crop and livestock yields, and other elements should be a fundamental component of programs to improve the management of farming systems. Improved management requires information of past and current practices on at least a field-by-field level. A major need is to establish user-friendly systems to manage the flow and analysis of information as part of a farming systems plan. Experience with programs such as the Dairy Herd Improvement programs or Iowa's Integrated Crop Management program show that record keeping is an important catalyst to prove the economic and environmental benefits of improved management. Record keeping and the derived information will be as important as the specific production practices specified in the plan. Policies that encourage or mandate the collection and use of information by producers may prove more effective than encouraging or mandating the use of specific farming practices. The information needed to manage a farm operation to maximize profit, if properly organized, provides much of the information needed to improve soil and water quality. The collection and synthesis of this information can point out ways to improve both profitability and soil and water quality. Record keeping should be mandatory when integrated farming system plans are the basis for granting financial assistance. It should also be mandatory when integrated plans are the basis for ensuring compliance with soil or water quality programs.

Other Issues

The report outlines a host of other information, research and policy needs. I will only touch on two others. The report strongly emphasizes the importance of targeting; directing technical assistance, educational effort, financial resources, or regulations at those regions where soil degradation and water pollution are most severe. It is also important to target those farms and farm enterprises that cause a disproportionate amount of soil and water quality problems. The inability or unwillingness to target policies, voluntary or nonvoluntary, at problem areas and problem farms is a major obstacle to preventing soil degradation and water pollution. Modern marketing methods need to be used to tailor technical assistance and educational programs to these target audiences.

One pressing need is to develop greater capacity, through the private sector as well as the public sector, to deliver the appropriate information and assistance that producers need to implement farming system ("whole-farm") management approaches. (And we must realize that this is far more complex than simply adding new pages of technical guides to a handbook.) Mechanisms should be developed to augment public sector efforts to deliver technical assistance with nonpublic sector channels and also to certify the quality of technical assistance provided through these channels.

Crop-soil consultants, dealers who sell agricultural inputs, soil testing laboratories, farmer-to-farmer networks, and nonprofit organizations are increasingly important sources of information for producers. In many cases, these private sources of information have become more important direct sources of advice and recommendations than public sources. Soil and water quality programs need to take advantage of the capacity of the private and nonprofit sectors to deliver information and education to producers. The potential to accelerate the delivery of technical assistance and information is great IF methods can be developed to certify the quality of the technical assistance provided through these channels.

Some Examples

Some examples of various program results may serve to illustrate the potential of these approaches. Summary data from a few Extension Demonstration Programs around the country (Extension Service, 1993) are exemplary: Maryland's statewide nutrient management program involved 14 county Extension staff who made recommendations for 112,320 acres of cropland. Adoption of recommended practices by participating farmers reduced their average annual rates of fertilizer application by the following amounts: 35 lbs. nitrogen (N) per acre, 41 lbs. phosphorus (P, as P_2O_5) per acre, and 32 lbs. potassium (K) per acre. This translates into total annual reduced amounts of nutrients potentially entering the environment of: 1,950 tons of N; 2,300 tons of P and 1,800 tons of K. A nutrient management program in Nebraska influenced participating farmers to adopt practices that reduced their average annual application of N to corn by 30 lbs. per acre over 300,000 acres. The total reduction of N fertilizer applied was 4,500 tons with no decrease in yield. This represents a savings to farmers of approximately $900,000. Through 1991, Illinois' Integrated Pest Management (IPM) program had helped to increase total IPM corn acreage to 62% of corn acreage in the state and total IPM soybean acreage to 59% of soybean acreage in the state. This level of adoption of IPM has resulted in reduced insecticide applications--from 69% coverage of the state's corn acreage in 1978 to 33% coverage in 1990. Also, over the period 1985-1990, average application rates of active pesticide ingredients were reduced by 22% for soybeans and 14% for corn.

In the 1980's, Iowa agricultural and environmental agencies began an aggressive statewide program of education and demonstration projects to implement integrated farm management approaches (Hallberg et al., 1991; Miller et al., 1995). These programs provide a myriad of farm, or project level results, such as cited above, but more importantly provide some larger scale insights. Improvements in management, particularly nitrogen management, are evident even in statewide summary data gathered by the National Agricultural Statistics Service and Economic Research Service (see Hallberg et al., 1991, for details).

In Iowa, as across the corn belt, fertilizer nitrogen use rose continuously from 1950 into the 1980s. In Iowa, fertilizer nitrogen use on corn rose reached a high of about 145 pounds an acre in 1985. Through the various efforts of Iowa's agricultural-environmental initiatives, positive changes in nitrogen management have been made. Nitrogen rates on corn have steadily declined, as opposed to the trends in most corn belt areas. Since 1985, Iowa farmers have reduced nitrogen rates for corn by about 20%, reaching a low of 114 pounds per acre (statewide average) in 1993, the lowest rates recorded since the early 1970s (Hallberg, 1996). Yet in 1992 and 1994 we set all time record yields. We have reduced nitrogen inputs, providing source reduction and pollution prevention, and have also reduced our input costs -- purchasing less synthetic fertilizer. (Iowa farmers have saved over $300 million since 1985.) But this has not reduced output, or yields; hence this also translates into improved economic performance and profitability as well.

These nitrogen reductions, across 10-13 million corn acres per year, result in reductions in nitrogen loading of 200-300 million pounds of nitrogen per year. This will improve water quality. But it will take time to see such improvements; partly because of climatic and hydrologic variability, partly because the changes are small and incremental and there are time lags in the system responses, and partly because there are still major improvements we need to make!

Time

As noted above, there are time constraints that we must consider in policy and programs dealing with agriculture and the environment. While we can measure source reduction efforts (e.g., Anderson, 1994), the ultimate proof must be improved water quality. But we must be patient. With the diffuse nature of NPS such problems took many years for us to recognize, and even as we improve our performance, it will take time to realize measurable water quality benefits (as noted above). But measure we must. Well designed monitoring programs must also be implemented as the key measure of success.

Also, there are many time constraints that affect the reality of program implementation. As noted, Iowa has developed very successful pilot programs to implement farming systems management approaches (Brown et al., 1994; Miller et al., 1995). This experience shows such approaches take 3-5 years to develop and implement on the farm. Implementation is a gradual process as the producer develops confidence in new approaches; it takes this long to adjust crop rotation factors, and to gather some of the field-by-field management histories necessary. Some changes must wait until a producer has the capital to purchase new equipment, or until it is time to replace equipment. As discussed above, it will also take time to develop the capacity, of trained public and private sector specialists, to deliver the farming system ("whole-farm") management assistance that producers need.

Time may be the major limitation for voluntary, flexible approaches that agricultural interests desire. Voluntary change in agriculture is a sociological as well as a technological process, and as such, change proceeds slowly. Even with the most aggressive of education and technical assistance programs, even when changes are economically beneficial, some producers are very slow to change. Again, we might look at nitrogen management as an example.

The rate of adoption of the use of fertilizer-N presents an interesting model (Hallberg, 1992). It took 10-15 years for farmers to adopt the use of fertilizer-N, even with the very clear and consistent message (from the private and public sector) that this would significantly increase production and profitability. (Even today in Iowa there remain some farm operators who do not use fertilizer-N.) Hence, as we attempt to refine nitrogen management, reducing fertilizer-N use and overall N-loading for environmental and economic efficiency, it will be difficult to expect any more rapid rate of change, particularly with mixed economic and policy messages. We are likely facing a generation of change to implement more systems management on a truly widespread basis in farming.

Summary

Improving the environmental performance of agriculture must be a primary consideration in the continuing evolution of farm programs and policies. The technical approaches outlined in the National Research Council's Board on Agriculture report Soil and Water Quality: An Agenda For Agriculture provide a framework that can improve the management and protection of agricultural-environmental systems and improve the economic performance of most farming systems, as well. While many of these approaches are being adapted within USDA programs, farm policy directions must strive to enhance and encourage their implementation.

In particular, farm policy should enhance and support efforts to develop and implement farming systems management approaches, that seek to: (1) conserve and enhance soil quality; (2) increase the efficiency of input use in farming systems; (3) increase the resistance of farming systems to erosion and runoff; and (4) make greater use and integration of field and landscape buffer zones. Implemented conjunctively, in a farming systems framework, these approaches can: provide pollutant source reduction, minimizing tradeoffs inherent in many single-minded best management practices; provide delivery reduction, improving the watershed or landscape's resistance and resilience to major hydrologic events; and maximize producers' ability to identify management approaches that enhance productivity and profit. Inherent in the farming systems approach is the need for better systems of farm record keeping to help producers identify win-win situations and realize economic benefits.

Further, support is needed to enhance programs that provide information needed to identify and target problem farms and farmers, and to evaluate and monitor program effectiveness. In addition to improved water quality monitoring (the ultimate evaluation), we need sociological and farm-level management information to assess technical assistance needs to implement farming systems approaches. We also must develop greater capacity, through the public and private sector, to deliver the information and assistance that producers need to implement farming system ("whole-farm") management approaches. And we must ensure mechanisms to certify the quality of technical assistance provided through these channels.

Amidst these efforts, we also must realize that agricultural ecosystems are inherently leaky; some adverse environmental impacts are inevitable, even under the best operational scenarios, simply because of the vagaries of climate. We also must realize that implementing an agenda to improve agriculture's performance will take time, and even after improvements are made, it will take further time to realize measurable, unequivocal water quality improvements. It will likely take a 'generation' of change to affect wide scale improvements, but even this will not happen without consistent, and systematic policy and program directions.

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Table 1. Members, Committee on Long-Range Soil and Water Conservation, Board on Agriculture, National Research Council, and authors, "Soil and Water Quality: An Agenda for Agriculture" (NRC, 1993).

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