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Citation Details

Ervin, David E. "A new era of water quality management in agriculture: From best management practices to watershed-based whole farm approaches." *Water Resources Update* 101 (1995): 18-28.

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A NEW ERA OF WATER QUALITY MANAGEMENT IN AGRICULTURE: FROM BEST MANAGEMENT PRACTICES TO WATERSHED-BASED WHOLE FARM APPROACHES?

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Why is reducing water pollution from agriculture such a stubbornly slow process? Despite several policy initiatives since the 1970s, farms and ranches rank as the primary contributors to impairments of the nation's surface waters [U.S.EPA, 1994b].² Emerging research also points to agricultural chemicals in many cases of groundwater contamination [Barbash and Resek; Mueller, et al.]. After a little reflection, the industry's negative distinction may not be surprising. Covering nearly half the U.S. land base, crop and livestock production inevitably alter natural vegetative cover, apply fertilizers, pesticides and irrigation water, and involve animal wastes. All of these processes can degrade water quality.

Without question, cases of water quality improvement as well as degradation occur within agriculture's number one ranking. Stream, lake, and groundwater success stories have come from federal, state, and local efforts. However, the overall weight of the evidence indicates the industry's performance needs to improve rather sharply if the nation's water quality is to advance to a higher plateau in line with broad public preference.

This paper's central thesis is that dramatic changes in program approaches are necessary for that advance because of powerful budget, economic, and political forces. Continued reliance on programs subsidizing or regulating best management practices (BMPs) conflicts with those forces in fundamental ways. Moreover, promising technologies and improved water quality science support more flexible, whole farm approaches for targeted priority watersheds.

Funding and Technical Challenges Impede Progress

Low funding levels have led the list of impediments to more progress. Although the sheer scope and nature of the production process almost guarantee widespread water quality effects, program support to remedy those problems has been meager. Consider that about \$80-\$100 billion of public funding was spent on water pollution

control during the 1980s. The major portion of that total went for control of pollutants from municipal sources entering streams, rivers, lakes, and estuaries. Yet, the combined funding for agricultural initiatives -- the Model Implementation Program (1970s), the Rural Clean Water Program (1980), the Water Quality Special Projects (1985), the USDA Water Quality Program (1990), and the Coastal Zone Act Reauthorization Amendments (CZARA)-- have totaled only \$1 or 2 billion over the last two decades. Although we might expect municipal water pollution control to cost more because of heavy construction requirements, the disparity is striking. Most of the agriculture-related water quality efforts have focused on planning and pilot studies. And, the major share of federal agricultural conservation program funding over the last decade has been aimed at erosion control with only secondary water quality purposes [U.S.GAO, 1995]. In short, water quality problems associated with agriculture have not been deemed a funding priority by Congress.

A key technical difficulty, the diffuse character of the agricultural water pollution process, may have contributed to low program funding. Farm and ranch water runoff and leaching problems usually come from widespread "nonpoint" sources such that the pollution can not be readily traced to definable points. The science describing the spatial and temporal processes and the ultimate environmental implications of nonpoint water pollution has been quite slow in developing. That means the offending discharges can not be easily identified, monitored, and controlled. Without better science, policy makers may be understandably reluctant to launch large-scale initiatives. But without making nonpoint problems a national priority, Congress inhibits the growth of necessary science. Enter the "chicken and egg problem", which should come first? In addition, the diffuse, insidious nature of much agricultural pollution does not prompt major program responses that often follow large environmental disasters such as rivers catching fire or tanker spills.

The vast diversity of the industry also poses special technical challenges for programs. Even if the nonpoint conundrum could be solved, consider structuring permissible effluent levels or technology standards for almost two million very different operations spread across the countryside. It is no wonder that the standard regulatory control approaches for other industries have played minor roles in agriculture. The industry's diffuse and diverse character make command and control regulations very costly to implement if not technically or administratively infeasible. Just the first step of monitoring agricultural pollutants has proven a very expensive task. Moreover, agriculture has displayed political prowess to resist the broad application of environmental regulations. The recent shift in political preference to favor approaches protecting farmer and rancher property rights should strengthen this resistance.

Doubtful Effectiveness of Current Federal Program Portfolio

Albeit with modest budget commitment, four approaches have been used to improve agriculture's water quality performance -- persuading operators to change damaging practices through education and technical assistance, subsidizing the adoption of new practices, regulating limited serious identifiable problems, and requiring certain practices in return for retaining eligibility for other federal agricultural programs. How have they fared?

The predominant federal approach has been and remains voluntary education and technical assistance programs (often accompanied by subsidies) to implement "best management practices."³ For example, the federal government sets water quality goals and standards (primarily for drinking water purposes), delegates responsibility for meeting the goals and standards to the states, and works with the states through a variety of programs that disperse education and technical assistance. There is little evidence that voluntary education and technical assistance programs produce significant changes in producer behavior unless accompanied by subsidies or regulation [U.S. Congress, OTA, 1995a].

Subsidy programs can significantly change producer behavior [Gale, et al]. Examples include the Agricultural Conservation Program (ACP)⁴ that shares the cost of installing practices, and the Conservation Reserve Program (CRP) that permits operators to voluntarily

retire eligible cropland for 10 years in return for annual rental payments. These programs, for the most part, have not been targeted to water quality and other environmental problems on the basis of the greatest social return for dollars spent [Osborn; USDA, ERS, 1986]. And, their enduring effects once the subsidies expire remain questionable. For example, a previous episode of land retirement in the 1960s revealed that farmers and ranchers will return the vast majority of retired lands to cultivation again [Osborn]. Unless the subsidies result in permanent shifts in farming technologies and land use that lower water pollution, the problems will reoccur.

With the exception of federal pesticide registration programs, environmental regulations have been sparingly applied to agriculture. The review and registration of pesticides to reduce excessive human and environmental risks is an indirect route to water quality. No doubt the screening and removal of these toxic substances has spared waters from deleterious effects. However, it is not clear that the registration process has performed well from broader environmental perspectives, and it may have hindered the timely development of more benign compounds [Reichelderfer and Hinckle]. The other principal regulatory effort has been to control point sources of water pollution, such as confined animal operations. However, the strictness of their application has been quite uneven across states [Connelly]. The implementation of CZARA in the early 1990s started down a path of requiring uniform adoption of minimum farm BMPs in all coastal zones, but has retreated from that regulatory approach after objections by many states. Although many states have submitted their CZARA plans for EPA approval, their approaches will be less regulatory than originally envisioned. In sum, the efficacy and cost of environmental regulation related to agriculture remains mostly undocumented and uncertain.

"Compliance mechanisms" are a final distinct approach. Introduced in the 1985 farm bill, they resemble regulation in that they tie continued eligibility for agricultural program benefits to acceptable erosion control and wetland alteration practices. These compliance schemes are not true regulations, however, because the farmers and ranchers can avoid the requirements by voluntarily foregoing the agricultural program subsidies. The USDA, in charge of implementing compliance measures, have declared the measures quite successful [USDA, ERS, 1994], while independent evaluations have raised questions about the extent of their efficacy [SWCS, 1992]. Regardless of their effectiveness, compliance schemes ultimately suffer the same budget vulnerability

as other subsidy approaches. Except where compliance requirements have encouraged operators to make enduring practice shifts that increased profit, their long-term efficacy is doubtful. Also, requiring operators of all farmland receiving agricultural program benefits to meet compliance standards spreads program resources across a wide array of lands rather than targeting efforts at the most serious problems.⁵

New Budget, Economic and Political Realities Conflict with Current Approaches

How might program reforms improve on this questionable record? A complicated set of budget, economic and political forces shape the context for policy innovation.

Pressures to reduce the federal deficit will likely decrease agricultural program funding leading to more reliance by farmers and ranchers on market prices rather than government programs. Members of both agricultural committees of Congress have proposed glidepaths for reducing agricultural program support over the next five to seven years. Proposals from the House and Senate floors are more extreme calling for outright elimination. The gradual erosion of agriculture's political base because of fewer farmers and rural representatives, coupled with unrelenting public sentiment to eliminate the budget deficit, has raised the pressure for program reform to unprecedented levels.

The final outcome is far from predictable, however, because agricultural subsidies have proved so resilient to attack. Some favor further restricting the portion of a farm's cropland eligible for government payments (termed increased "flexibility"), and allowing farmers to plant a wider range of crops on the "non-supported" lands. Others simply want to gradually phase down the price and income support levels and eventually eliminate payments after a certain period. Still others want a combination of both. Virtually all proposals share two common objectives -- increase the farmer's reliance on market prices for production decisions and increase the operator's flexibility in choosing crops.

Federal budget pressure will also likely constrict traditional subsidy approaches to resolving agriculture's water quality problems. Evidence for this proposition is accumulating. A 1993 decision suspended further CRP enrollment (much of which would have been targeted to

water quality problem areas) in favor of food assistance programs. Another 1994 decision halved ACP program funding. It is noteworthy that both actions were taken by a Democratically-controlled Congress. The battle continues with current farm bill debates about funding conservation programs, such as the CRP, and other environmental initiatives. The budget lesson is clear. With a smaller budget pie, each slice becomes relatively more valuable and political competition grows more fierce.

If significant commodity program reform materializes, some general implications for water quality emerge. Perhaps the most obvious consequence of phasing down agricultural commodity programs is the decreasing leverage for environmental compliance programs. As noted above, the overall effects of compliance measures on soil erosion control and wetlands protection are positive but debatable as to degree. Complete removal of commodity program incentives will remove virtually all compliance leverage and likely result in increased erosion and wetland alteration, unless substitute programs are implemented.

Effects on land values caused by commodity program reform could also play longer-term roles. To the extent commodity programs effectively restrict the supply of farmland through required set asides and the CPR, or otherwise raise the price of farmland, land values will fall if reform lessens those provisions. Lower land prices relative to non-land inputs will encourage the use of more land and less non-land input use per acre, such as agrichemicals [Miranowski, et al; Tobey and Reinert]. The total national use of fertilizers and pesticides depends upon the offsetting influences of lower application rates per acre versus more land in production. Overall erosion would rise as the cultivated land base expands. Simultaneously, farmers would shift their cropping enterprises to grow less of the program crops receiving lower support and more of those crops in demand by market forces.⁶ For example, the acreage of program crops such as corn and wheat may fall, but soybean and hay production could rise in some regions. There is also evidence to indicate that commodity programs, by artificially supporting crop prices, have masked the effects of soil erosion and thereby inhibited conservation investments that often benefit water quality [Orazem and Miranowski].

Ultimately the total impacts of these land use shifts on water quality depend on the environmental programs in place, not on the changes in crop and livestock enterprises and production practices. However, it is

instructive to anticipate any shifts in production pressure that will help anticipate water quality program needs. The potential for water quality damage or improvement depends on the how the particulars of reform interweave with local agriculture and resource conditions. Simulation analyses have shown both regional decreases and increases in water pollutant loadings under possible program reform paths [Miranowski, et al; Ervin et al.].

Of particular interest, farm-level responses should vary widely due to their broad diversity and differing dependencies on agricultural benefits. In the longer-run, greater capacity to adjust to the changes would be expected as farmers and researchers develop new technologies to use more of the less expensive land and fewer non-land inputs. Properly signaling the need for technologies that attain water quality objectives while simultaneously maintaining profit is a key public policy action.

Superimposed on this potential agricultural program reform path are powerful forces pushing the industrialization of agriculture [U.S. Congress, OTA, 1995a]. Fewer and fewer farms and ranches are producing more and more of the output and controlling more land and water use. And these industrial-style farms are vertically integrating their input, production and marketing processes to control price risk, product quality, and better deliver the foods demanded by domestic and foreign consumers. Global economic integration forces building for the last two decades, enhanced by recent global and regional free trade agreements, will likely exacerbate the industrialization trend.

The industrialization trends will eventually make it necessary to deal with fewer units in implementing water quality programs (and easier to implement regulations). Many also expect that operators of industrialized farms will be better able to develop, adopt, and adapt environmental technology measures because of higher management capacity. Firm evidence for or against this expectation is lacking. A wide range of farm types could emerge from the industrialization process, including concentrated animal confinement operations, vertically integrated specialty crop production, processing, and marketing ventures, and simply larger land-extensive crop and livestock farms. While all must make a profit in the long term, different managers, even within one of the farm types, can take very different approaches to environmental protection depending upon their preferences, skills, and other factors. Such a wide diversity argues against standard BMP approaches to water quality.

The size of industrial operations may reach a point that eventually hinders site-specific approaches to water quality. Furthermore, the larger production units, especially for animals, concentrates wastes and raises the specter of large pollution spills that could precipitate tighter regulation. Others fear that the divorce of ownership from management that seems to accompany industrialization may translate into a loss of farm conservation incentives. One point is clear -- the full implications of agricultural industrialization for progress on water quality are unclear. The fundamental point remains -- without a set of effective water quality management institutions in place, industrialization will lead to cases of improvement and degradation with a uncertain total impact.

Recent political events and surveys have delivered mixed messages for environmental management. Public opinion polls taken after the 1994 elections show the vast majority of citizens want more water quality improvement [USDA, NRCS, 1995]. But the apparent shift to political conservatism revealed by the 1994 elections portends more reliance on state and local government approaches emphasizing private initiative, and less on federal intervention. The calls in agriculture for regulatory reform and reversing losses in private property rights illustrate this trend. It is too early to tell the duration and eventual outcome of this political shift, or whether it simply reflects short-term frustration with old programs that unnecessarily restrain private innovation and flexibility. But the need to downsize the budget deficit reinforces the message of less reliance on federal subsidies and centralized planning of BMPs. Some role for federal action will likely be necessary to resolve water quality problems that transcend state borders (transboundary problems), and to ensure national public goods involving multiple states, e.g., habitat protection for migratory wildlife. But the dominant movement for agricultural water quality problems appears headed to state, local, and private levels for political and federal budget reasons.

Understanding these budget, economic and political realities defines social forces affecting feasible policies. But they describe only part of the picture and mostly constraints. An examination of trends in technology development and the latest scientific evidence about agriculture's role in water quality helps define opportunities. That knowledge helps identify promising approaches to priority problem areas that hold the largest potential environmental payoffs.

New Technology Enables Positive Economic and

Environmental Performance

Agriculture is in the midst of an accelerating technological revolution [U.S. Congress, OTA, 1992]. The path that technology revolution travels will not only affect the nature of the industrialization process but the capacity of farms and ranches to achieve environmental objectives. Biotechnology, advanced information systems for input application, and biologically-based pest controls are just a few that could transform food and fiber production. The full impacts of these technologies are almost impossible to fathom, much as we failed to anticipate the extraordinary power of mechanical cultivation or synthetic fertilizers and pesticides during this century. Many of the new technologies hold the potential for water quality improvement. Yet virtually all are being developed with a dominant focus of increasing productivity, and accidental or scant attention to environmental effects. The lack of public and private incentives for joining agricultural production and environmental objectives in technology research and development lies at the heart of the problem.

The dominance of production-related research is reflected by nearly two thirds of public research funding going to crop and livestock production categories, and only about 10 percent for natural resource and environmental topics [USDA, CSRS]. It is understandable that private technology development responds most forcefully to productivity and profit potential. But the strong public sentiment for water quality improvements would seem to support relatively more public research on natural resource and environmental management. Indeed, a compelling argument can be made for integrating production and environmental objectives such that new technologies not only enhance productivity and maintain profit, but contribute to environmental objectives as well [U.S. Congress, OTA, 1995a]. Without clear public policy signals for such research and technology development, these "complementary" technologies will languish. In the absence of better integration of production and environmental objectives, the very real possibility exists that many of the promising technologies will cause further water quality degradation.

Several advances over the past few decades give ample reason to believe the potential for complementarity is real. Conservation tillage (CT), soil nutrient testing (SNT), and integrated pest management (IPM) may be the most recognizable examples. Both the private and public sectors have played roles in their development and application.

A variety of CT systems are transforming crop production across the nation, now approaching 40 percent of the planted acres [USDA, ERS, 1994]. Increasing application indicates the systems are profitable for many farms by saving fuel, labor, and machinery costs and only slightly increasing aggregate fertilizer and pesticide amounts, but maintaining or improving yields [USDA, ERS, 1994]. The total water quality effects of CT are often presumed positive. By retaining more plant residue on the soil surface, CT systems reduce erosion and water runoff carrying sediment and agrichemicals to surface waters. However, there is evidence that the increased infiltration that accompanies less runoff may cause greater groundwater contamination risks in some areas [Barbash and Reseck]. So the net water quality effect of CT remains uncertain where groundwaters are vulnerable. In general, both the profit and environmental performance of CT, and for that matter most other potential complementary technologies, will vary by specific farm and natural resource conditions. This basic insight has profound implications for water quality programs. The likelihood of a "technology silver bullet" for improving agriculture's water quality performance is remote if not impossible. Site-specific assessment and management decisions are necessary to ferret out the most appropriate responses for each farm.

Soil nutrient testing also appears to satisfy the dual profit and environmental improvement criteria in some areas. For example, recent evidence shows Pennsylvania farmers voluntarily reduced their nitrogen fertilizer applications by about one third when using pre-sidedress soil nitrogen testing [Musser, et al.]. The cost savings translated into profit increases from \$3.70 to \$13.50 per acre and reduced excess nitrogen in the soil profile that could migrate to surface and ground waters. The Pennsylvania findings corroborate those for a similar analysis of Iowa farmers [Babcock and Leamer].

A recent comprehensive review of the performance of integrated pest management (IPM) also concluded that the application of those systems generally improved profit and lowered pesticide applications [Norton and Mullen]. Potential water quality improvements must be inferred from lower application levels. As for CT, the IPM and SNT findings of complementarity pertain to specific farms and areas. Generalization must proceed very carefully based on agricultural and resource conditions.

A number of other technologies appear poised to offer

substantial complementary benefits [U.S. Congress, OTA, 1995b]. Preliminary results indicate management intensive grazing systems often used in dairy systems can increase profit, lower grain production requirements, and reduce risks associated with concentrated animal waste storage and disposal. Organic crop production systems involve no synthetic pesticide or fertilizer applications, plus build better soil structure to retard other water pollution. "Precision farming" refers to site-specific management of fertilizers, pesticides, and irrigation water within fields. This family of technologies uses advanced information systems, such as nutrient testing devices, yield monitors and global positioning systems, to offer the potential of reducing excessive input applications that can impair ground and surface waters. The development and application of these promising technologies is now principally and understandably guided by private profit motives. Those motives will include some private on-farm soil and water conservation incentives, but will not incorporate off-farm water quality objectives unless public or private institutions create incentives to do so.

An overarching and common-sense lesson emerges from this review. The application of these technologies to improve profit and environmental conditions depends upon site-specific farm/ranch and natural resource conditions. Universal prescriptions of BMPs for certain classes of resources within even a relatively small region, let alone national coverage, will miss important differences in farm goals, management ability, varying assimilative capacities of natural resources to degradation, plus a host of other factors. Sufficient management expertise appears to be the critical factor in successfully applying this new generation of technologies [U.S. Congress, OTA, 1995b]. Thus new water quality programs for agriculture that emphasize the application of complementary technologies will need to find public or private ways to deliver that management training,

Improved Science Helps Identify Priority Targets

The challenge to fashion water quality programs that foster site-specific management and technology innovation is coming into focus. But is there sufficient science to support this site-specific thrust in the policy process? In other words, can we be reasonably sure that we are not missing important targets and wasting public resources? Do we understand the interrelationships among various environmental media well enough to factor in compounding or offsetting influences on water quality? Can we develop performance criteria to guide the development and application of such programs that

encourage private sector innovation and flexibility?

Any self-respecting scientist studying agriculture and water quality will likely answer a resounding no. We always need better science almost by definition. This paper has already explained the challenging technical problems posed by agricultural nonpoint pollution and the low scientific funding on those issues. But consider three themes of recent scientific advances related to agriculture and water quality to see if a modest beginning at program restructuring is feasible.

First, research institutions are systematically developing a better understanding of the regional and state patterns of water quality related to agriculture. Most notably, the U.S. Geological Survey's activities, including the National Water Quality Assessment (NAWQA) program and other efforts, are helping identify the role of agriculture in water quality around the country. Although these assessments do not constitute a representative sampling (because available information bases do not permit such a sampling), they are the most complete scientific appraisal of water quality processes to date. Regrettably, the U.S. Department of Agriculture's comprehensive natural resource database on non-federal lands, the National Resources Inventory (NRI), does not collect water quality information to augment the NAWQA data.

Preliminary findings from the NAWQA analyses support the general conclusion that agriculture plays a leading role in surface water quality problems and nutrients in groundwaters in many regions [Mueller et al.; Smith, Schwarz and Alexander]. Results on pesticides in groundwater quality are not yet complete but should be available shortly [Barbash and Resek]. This broad assessment also stresses that water quality conditions related to agriculture vary considerably by region and by watershed. The regional and local diversity in environmental processes surfaces again.

The USGS assessments also draw on related water quality appraisals conducted by state and local scientists and government agencies working with USGS staff. The resultant total database was judged sufficiently reliable to identify the 10 highest priority problem areas for improving surface water quality related to agriculture [U.S. Congress, OTA, 1995b]. A similar assessment for groundwater problems should be possible in the near future. Thus science concerning water quality problems related to agriculture has advanced such that priority targets can be selected for focusing program efforts rather

than addressing general classes of problems and lands.

Second, a near scientific consensus seems to be developing that water quality management needs to proceed on a watershed basis [Knopman, et al, 1994]. Field by field and farm by farm approaches to water quality taken in the past are increasingly seen as piecemeal efforts with low likelihood of producing effective and enduring solutions. Because streams, rivers, lakes and aquifers are interlinked in hydrological systems, designing measures to affect an area's water quality necessarily requires consideration of components in the system. For example paying to retire highly erodible cropland in one part of a watershed may be negated by other farms plowing steep pasture lands when crop prices jump.

The recognition that water quality processes are governed by larger environmental units than fields or farms is fundamental to guiding site-specific management actions. For example, NAWQA assessments have used watersheds as basic building blocks. There is considerable science to guide these watershed efforts [U.S. EPA, 1994a]. However, adaptive management, a process of using management programs as experiments and allowing for feedback, will likely play a role as we learn more about how to manage diverse landscapes [Lee]. Some existing programs already operate on this basis, such as the special hydrologic unit area designations as part of the USDA's water quality programs. Many state programs are also organizing water quality efforts around the watershed concept. So this scientific principle to help build better water quality programs is already being used, but needs to be more broadly embraced by a new generation of programs.

Finally, science increasingly accepts the need to incorporate the interrelationships among environmental processes within ecosystems in management approaches [Morrisey]. Water quality invariably depends on soil quality and may depend heavily on air quality as evidenced by nitrogen deposition from atmospheric sources [NRC, 1993]. Also, water quality not only affects human health but also influences the condition of aquatic habitat for wildlife using the water resources. Thus setting water quality performance levels requires explicit recognition of those interacting effects to attain ecosystem health. The science of ecosystem management is gaining ground but quite immature. At this point it is not possible to formulate water quality performance targets based on full ecosystem interactions. But the need to recognize those interactions should not constrain approaches that

partially incorporate known interrelationships, such as working on soil quality as a buffer to water pollution.

Taking Some Preliminary Steps to Program Reform

Federal policy developments for agriculture and related environmental issues have generally taken modest incremental steps. The compliance mechanisms of the 1985 farm bill and the CZARA could be interpreted as exceptions to that generalization, but in practice they have departed less from the traditional mold than expected upon passage. Some have argued that the incremental approach is not only preferred for political reasons but also justified when science is uncertain about the effects of large dramatic shifts [Lindblom].

If the budget, economic, and political trends are indeed forcing a reconsideration of water quality programs, the 1995 farm bill and Clean Water Act reauthorization are opportune times to experiment. Clearly, large federal initiatives of the old subsidy variety will be difficult if not impossible under the current budget-cutting pressures. Fresh approaches that empower more state and local efforts, allow private flexibility, encourage complementary public/private technology development, and concentrate program efforts on priority areas stand the best chance. Rarely do political circumstance and emerging science so nicely converge to provide mutual support for program innovation.

Three basic steps flow from the examination of social trends, technology developments, and scientific advances. There is only space here to outline their general nature, but the implicit principles could guide a new generation of programs.

Target program efforts at priority areas and watersheds.

More effective targeting conserves scarce budget resources, lessens unnecessary burdens on farmers and ranchers that can constrain competitiveness, and gives a better chance of developing a critical mass of program resources to deliver water quality improvements. To a limited extent, this type of targeting is already underway in post-1990 CRP enrollments and some agricultural water quality programs. However, it remains incomplete and would benefit from Congressional sanction in the farm bill and Clean Water Act.

In addition to understandable political resistance from

redistributing program funds, targeting has been inhibited by incomplete databases and immature science, especially at the national level. However, those obstacles can be overcome by employing a panel of leading scientists and other experts to identify water quality priority areas [U.S. Congress, OTA, 1995b.] This selection process has the advantage of panelists augmenting the best published data with expert judgment, theirs and colleagues, to fully exploit the scientific base. Federal agencies responsible for water quality management related to agriculture could structure such a targeting process that first involved national-level designations, to be followed by state and local processes that refine targets within those designations. By illustration, large portions of the Corn Belt may be selected as prime contributors to water quality degradation in the Lower Mississippi River system, but representatives from Iowa, Illinois, Indiana, Missouri, and Ohio could further delimit the key watersheds requiring program attention. This joint federal-state-local process would not apply of course to water quality efforts initiated solely within the states.

Devise Simplified Strategic Programs for Targeted Priorities

At least 40 separate federal programs apply to environmental management related to agriculture [U. S. Congress, OTA, 1995a]. A large number of those programs directly or indirectly pertain to water quality. Farmers and ranchers can understandably incur high administrative costs in dealing with these multiple education, technical assistance, subsidy, compliance, and regulatory efforts. Also, they may have the frustrating experience of conflicting program rules, if not at the federal level, then between state and federal programs. Pleas for program simplification are therefore not surprising.

The simplified structure could follow three general strategies [U.S. Congress, OTA, 1995b]:

- Promote the adoption of "readily available" complementary technologies, e.g., CT, IPM, and SNT, primarily through education and technical assistance efforts to enhance management skills.
- Encourage other technologies through incentives or disincentives that involve some cost but achieve environmental objectives and keep land in production, e.g., riparian buffer strips, waste lagoons.

Voluntarily retire selected farmlands for long periods when foreseeable agricultural production and desired environmental performance are incompatible, e.g., critical wetlands and very highly erodible lands in non-attainment watersheds.

Traditional program efforts heavily emphasize the second and third strategies using subsidies, but will run up against continuing budget pressures. The new approach would place most emphasis on the first strategy that takes maximum advantage of private incentives and thereby lowers public cost. It would also be backed up by vigorous public/private research and development programs to deliver more complementary technologies for water quality. A major weakness of past farm bills has been inattention to such environmental technology in the research title.

It is unrealistic to expect that complementary technologies will apply to all situations, especially in the short-term, or that they will do the entire job. However, they merit first consideration for cost and private flexibility reasons. Where they are not available or are insufficient to remedy the problems, the second approach can be applied, always seeking the lowest cost measure that provides the greatest likelihood of enduring private protection. Only as a last resort would farmlands be retired with full public payment.

Use Whole-Farm Approaches to Implement Program Strategies

For political and economic reasons, greater emphasis on private initiative will be necessary to make significant progress on water quality in agriculture. Centralized programs pushing one-size-fits-all BMPs run counter to prevailing political sentiment and good economics. More flexibility for operators to design site-specific approaches will generally lower the private and public cost of meeting water quality requirements. The operator is in a unique position to consider all of the technical, economic, and resource relationships that must be balanced to meet private goals or public purposes. The need to consider the full set of ecosystem relationships in water quality management noted above has a corollary in farm and ranch management.

The concept of a whole farm management plan to integrate and coordinate private production decisions across farm enterprises has been around for decades. But now it is being extended to include natural resource and environmental management considerations. Yet there has been little systematic study or development of this broader version. Despite some fears that the plans risk federal land use restrictions, just the opposite of what is intended,

the concept enjoys broad appeal in political, scientific, and industry circles. However, we are in uncharted territory to a large extent. These plans should be very different from past exercises of constructing lists of best available technologies.

Conceptually the planning process begins with an assessment of on-farm natural, human, and capital resources and all off-farm environmental resources affected by the operation. It is essential that the watershed and ecosystem interactions described above be incorporated to capture the full off-site implications of farm actions. A plan is then prepared to integrate production and environmental management within the unique resources, management, and other farm attributes. Relying on whole farm plans to meet multiple program requirements should not only exploit farmer ingenuity but reduce compliance burdens. They may also serve as a form of regulatory relief if successful application of the plan is ruled as satisfying wetlands, water quality, and other requirements, and therefore receiving immunity from suits brought under environmental statutes.

Four minimum conditions must be met before this modern version of whole farm planning can realize its substantial potential [Ervin and Smith]. First, explicit and measurable environmental performance targets must be established to guarantee the achievement of public objectives. Implementing a plan that satisfies these performance targets gives the farmer incentive to avoid the alternative program out of regulation and other forms of compliance. Second, all agencies and stakeholders must be involved in the setting of those environmental targets to avoid later reversals or unnecessary actions. Achieving agreement among multiple federal agencies and companion state agencies will be a huge task, not to mention industry and environmental groups. Third, the farmer must participate voluntarily to assure the performance targets and guidelines are not so demanding or inflexible that they negate private innovation and volunteerism. Finally, the whole farm monitoring and certification should be privatized. Existing federal agencies simply do not have the resources or expertise to construct the diversity of plans that will be demanded. The government's role can be one of licensing and overseeing the private planning industry.

These steps are of course only sketchy outlines of action. Other perplexing questions and challenges remain. Who will provide the leadership for bringing such proposals before Congress and mustering the necessary political support? Ideally, a coalition of private agricultural and

environmental groups are best equipped to fashion a workable approach that satisfies both major interest groups. The farm and ranch industry needs to recognize that the program path of mostly voluntary/subsidy programs has not abated the public's desire for water quality improvements. In fact, the majority of that public favors increased regulation, even after the 1994 election [USDA, NRCS, 1995]. So proactive efforts by the agricultural industry may avert poor decisions. Lobbying for increased research on complementary technology development would be a natural early action.

The environmental groups should recognize that the old-style command and control regulation so often relied on for other industries will not produce the same results in agriculture for good technical and economic reasons. If it is tried and found unworkable, the strategy could backfire causing worse water conditions as the programs are disassembled. Their main challenge should be to lead the definition of reasonable environmental performance targets that farmers and ranchers can respond to in innovative ways. Here, the scientific community, government and academe, must step out of its ivory towers and provide the best information upon which to make tough judgments when the environmental processes and possible outcomes are inherently uncertain.

Finally, what agencies will collaborate to provide the necessary program integration to carry out a new generation of programs? Experience with present water quality programs does not indicate the federal agriculture and environmental agencies work that well together. This outcome should not be surprising because they have very different primary missions, enhancing production or protecting environmental quality. Perhaps a new generation of approaches with redefined roles of mostly assisting private sector solutions would help solve the territorial disputes. Congressional programs that help tie production and environmental quality goals and actions together would help neutralize the old tension.

Notwithstanding these remaining challenges, targeting high priority areas and implementing simplified programs under whole farm approaches responds to the prevailing budget, economic, and political conditions. Moreover, recent advances in science and technology development give encouragement that public and private costs can be kept down in making enduring progress on water quality.

Endnotes

¹ Serving as Senior Analyst, Environment Program, Office of Technology Assessment, U.S. Congress while

this paper was prepared. I have benefited from extensive discussion with Elisa Graffy on water quality issues related to agriculture, and from helpful comments by Benno Warkentin and Jeff Zinn. Any remaining errors remain my sole responsibility.

² More specifically, agriculture was identified as the primary source of pollution to rivers, lakes, and coastal estuaries in 32 states [US Congress, OTA, 1995a]. Because not all states reported sources of pollution to rivers and streams, and to lakes, ponds, and reservoirs, the total of 32 could underestimate agriculture's role. Some in scientific and policy communities may quarrel with the quality of these EPA data because a standard protocol is not used to ensure high quality, comparable information from all states. Indeed, such a protocol can not be legally instituted under current federal statutes. However, other independent scientific assessments are corroborating agriculture's key role [Barbash and Resek; Mueller et al; Smith, et al].

³ These management practices are "best" in the sense that they are considered technically feasible and effective in controlling water pollution, and *estimated* to be cost effective. The cost effectiveness determination for hypothetical farms and ranches can be misleading in program application because it can not capture important farm-specific factors, such as management expertise, special resource conditions, and other important influences on environmental and economic performance.

⁴ The Water Quality Incentives Program (WQIP), approved in the conservation title of the 1990 farm bill, is a good example of this approach--in return for implementing approved water pollution control practices, operators receive financial assistance to offset some of the practice costs. The WQIP was designed as a stand-alone program, but was eventually implemented as a special practice under the ACP. Although the program was expected to be a major initiative, annual appropriations total are only \$15 million, with less than \$60 million expended to date. Reasons for the low level of funding likely stem from political conflicts among agricultural and environmental interest groups and government agencies, plus continuing budget pressure.

⁵ The same criticism can be leveled at the wetlands alteration compliance scheme known as "Swampbuster" which applies to all wetlands on farms enrolled in agricultural programs.

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