Invited Presentation

Commercial Agriculture and the Environment: An Evolutionary Perspective

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The decade of the 1980s saw a resurgence of concern over the environmental and health effects of agricultural production that exceeded even the concern in the sixties generated by the publication of Rachel Carson's book, *Silent Spring*. Consumers worried about the health effects of pesticide residues on foods; conversion of wetlands to crop production was blamed for the decreased population of migratory waterfowl; rural residents worried about the effects of nitrates and pesticides found in their groundwater supplies; and sediment, nutrients, and pesticides in surface waters were blamed for the decline of estuaries such as the Chesapeake Bay and contributed to problems in freshwater and coastal fisheries.

As a result of this concern, many changes occurred. The first involved changes in policies. New farm programs designed to protect the environment, such as the Conservation Reserve Program (CRP), and sodbuster and swampbuster restrictions, were incorporated into the Food Security Act of 1985 (FSA). The Federal Insecticide Fungicide and Rodenticide Act (FIFRA) was revised to speed up the timetable for reviewing older pesticides. The revised Water Quality Act of 1987 directed states to develop management plans to control nonpoint source pollution. States became very active in passing legislation to protect groundwater or to restrict agricultural activities in environmentally sensitive areas.

There were also changes in technology, including widespread adoption of reduced tillage for corn, and new environmentally safer products, such as pesticides that break down rapidly in the environment.

Consumer markets evolved to provide organic or certified pesticide-free produce alongside produce grown using pesticides. Many baby-food producers have limited the number of pesticides their growers can use. California required all producers to issue a warning if their products contained any chemical known by the state to cause cancer or reproductive disorders.

Finally, information, though still scarce, continued to accumulate about the extent of contamination of ground and surface waters from agricultural chemicals and about the health risks from pesticides and nitrate residues.

The changes that occurred in the 1980s have created a need to reevaluate the problems associated with agriculture, resources, and the environment. For some of the environmental problems related to agriculture, evolutions in policies, technologies, markets, and information have acted in consonance to reduce or eliminate the problem. Other problems have tended to persist. What I would like to do in this paper is take the four environmental problems listed at the outset and trace the evolution of each over time as information, technology, markets, and policies have changed. The goal is to develop a framework of analysis that provides a better understanding of why some environmental problems tend to persist over time while others succumb to evolution in policies, technologies, markets, and information.

There is another reason why such an assessment is timely. The United States Department of Agriculture (USDA) and several other federal agencies are currently engaged in a five-year project called the President's Water Quality Initiative (WQI). The goal of the project is to determine how far policy makers can go in reducing groundwater pollution from agricultural chemicals using voluntary technical assistance and cost-sharing programs. The feeling in Washington is that this is USDA's last chance to show that voluntary programs are sufficient to reduce groundwater pollution from agriculture to a socially desirable level. If the USDA does not succeed with this effort, the Environmental Protection Agency will be allowed to impose a regulatory solution.

The question posed by the WQI is interesting.

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Just how far can we go with voluntary technical assistance and cost-sharing programs at the federal level to achieve our environmental goals? The knee-jerk reaction of most economists, myself included, is that we cannot get very far with voluntary programs because the environmental problems of agriculture all involve some sort of market failure, that is, situations where the costs or benefits of a farmer's production decisions are not fully borne by the farmer. As is well known, in such situations, private decisions do not produce a socially desirable allocation of resources.

On closer inspection, however, some of the environmental problems of agriculture that were once considered to be market failures have been found not to be market failures. The on-farm effect of soil erosion is an obvious case, but there are other cases as well where institutional and technical innovation, coupled with increased information, have reduced or eliminated past Pareto-relevant market failures.

Framework of Analysis

The environmental problems of agriculture are related directly to a farmer's production decisions and the physical environment in which the effects of those decisions are realized. A farmer's decisions occur at both the extensive and intensive margins. Extensive-margin decisions involve choices about how much land to cultivate. Intensive-margin decisions involve the level of intensity of use of the land, such as pasture vs. cultivated cropland, and choices about the rates of application of nonland inputs, such as labor, machinery, and agricultural chemicals. Whether or not the production decisions of farmers lead to socially desirable outcomes or create environmental problems depends on the decision environment and the physical environment that the farmer operates within.

Production decisions are determined by the set of market and nonmarket incentives a farmer faces. In analyzing a farmer's decision environment it is necessary to examine whether or not prices received and paid fully reflect social opportunity costs, that is, whether there are genuine market failures or price distortions due to policies that cause a divergence between private and social cost. Recent polls (Reichelderfer 1990) have indicated that a farmer's nonmarket incentives may also be an important behavioral motivator. These nonmarket incentives include such lofty things as community and cultural values, the idea of being a good neighbor or steward of the land, as well as such basic concerns as who suffers the health risk from applying pesticides. If the wind blows the pesticide into the farmer's house or the water washes it into his well, he may be more likely to take precautions than if the pesticide washes downstream into the neighboring city's water supply.

The market and nonmarket incentives faced by the farmer are determined by available technologies, policies, markets, and information. While there are many interactions among these factors, they are discussed individually for heuristic purposes.

The primary technological issue is whether or not there are alternatives available that would correct the environmental problem from society's perspective. Tying technology back to incentives, if an alternative is available, we also need to know if it is in the farmer's best interests to adopt it. Finally, if it is not in the farmer's best interests to adopt it, we need to know what policies—regulatory or voluntary—would lead to adoption.

An increasingly important determinant of a farmer's decision environment is the existing or impending web of regulations, institutions, and policies at the federal, state, and local levels that affect a farmer's incentives. Some programs, such as target and support prices, give farmers incentives to produce crops that require high levels of application of pesticides and fertilizers. Others, such as the sod- and swampbuster provisions of the farm bill, offer subsidy-dependent incentives to not convert fragile lands to crop production. The threat of impending regulations may also be an important motivator of current decisions. For example, Boggess, Flaig, and Fonyo found that farmers were a lot more likely to accept cost sharing to adopt best management practices (BMP) to manage dairy waste in Florida after regulations were threatened that would require dairies to meet performance standards for effluent.

The third factor is consumer preferences and the institutions that make up the market system for inputs and outputs. If consumer preferences shift toward consuming organic produce or foods with reduced levels of pesticide residues, this will only give farmers an incentive to reduce or eliminate pesticide use if a market channel exists for selling that produce and the price premium is high enough to justify the higher production costs. The federal organic certification program and the use of secondary residue-testing services by some supermarkets in California create the institutions needed to sell such produce if the market demand is high enough.

Finally, both the decision environments of the farmer and of society are dynamic in that they depend on available information and the technologies available for processing information, both of which evolve over time. For example, use of herbicides has been shown to lead to groundwater pollution in certain regions of the country. However, it is only fairly recently that these herbicides have even been detected, so knowledge about where herbicide use is a problem and which herbicides are prone to leaching is still limited but continues to grow. We also have extremely limited information as to what the social costs of herbicide residues in water are. Increasing our knowledge about which areas are prone to groundwater contamination by herbicides and the social cost of that contamination will help regulators focus their attention on real problem areas, and the information alone may give farmers in those areas incentives to reduce the infiltration of herbicides into groundwater.

The farmer's decision environment and the nature of the policy problem depend on the physical environment in which the production decisions of the farmer are realized. For example, in part, farmers base their production decisions on the characteristics of the farm resource base and environment. Use of irrigation in arid regions and soil conservation practices on highly erodible land are obvious examples. However, it is less obvious whether or not farmers take such factors as groundwater vulnerability into account in deciding the type and timing of chemical application.

The policy problem is greatly affected by the physical environment. Answers to questions about whether or not the problem is limited to a few vulnerable localities or is endemic, and whether or not a small or large number of polluters are involved, all affect the types of programs that can be implemented and the appropriate level of policy making, be it federal, state, or local.

Before applying the framework of analysis to the four environmental problems, it is instructive to apply it to a real-world case study of pollution from dairies in Florida compiled by Boggess, Flaig, and Fonyo. The authors trace the evolution of dairy pollution policy in the Lake Okeechobee region of Florida as information about the sources, pathways, and social cost of the pollution grew over time, and as regulators and farmers gained experience concerning which technologies and programs were effective.

Policies for dairy waste management in the Lake Okeechobee basin have evolved from voluntary adoption of best management practices (BMPs) with full cost sharing in the early 1970s, to voluntary adoption with partial cost sharing, to a regulated best-available-technology standard with partial cost sharing, to phosphorus performance standards without cost sharing in 1992 (Boggess et al., p. 19). According to the authors, the implications of this study are: "One of the most obvious implications of the Lake Okeechobee experience is that programs designed to solve complex, nonpoint pollution problems are going to be evolutionary in terms of their complexity, rather than revolutionary. The political process of dealing with the uncertainty and lack of information about the problem and alternative solutions, equity concerns (including property rights/taking issues), and administrative inflexibility once programs are put in place, all but guarantee a cautious, step-by-step approach. In the case of Lake Okeechobee, key components of the nonpoint programs have evolved in complexity over time including technologies, monitoring programs, and incentive mechanisms. The evolution of technologies is in effect converting a primarily nonpoint source into a point source" (Boggess et al., pp. 18–19).

The Lake Okeechobee example is not intended to imply that all agricultural nonpoint pollution problems will evolve into point sources that are regulated by performance standards, though certainly some will. The particular evolution of policies that the case study illustrates is a function of the environmental characteristics and political climate in Florida. The study does, however, shed light on the ways that farmers and regulators respond to changing incentives, technology, institutions, and information.

Applying the framework, runoff from dairy farms is a classic market failure. The effluent is an unpriced externality that imposes costs on society in the form of environmental degradation. In the particular region of Florida, dairy runoff is purely a surface water quality problem, mainly from phosphorus. Because there are no significant damages to groundwater, the farm operator has no incentives to correct the problem, since all costs, pecuniary and nonpecuniary, are felt off the farm site.

There are a wide set of alternative technologies available to reduce dairy waste, ranging from directing dairy runoff to lagoons to complete confinement operations where all solid and liquid wastes are treated on site. Each of these alternatives will reduce pollution with varying levels of effectiveness, but each costs the farmer something to install, operate, and maintain without producing any offsetting private benefits. Consequently, it is not surprising that voluntary BMPs, even with 100 percent cost sharing, were not highly effective in controlling the problem.

The policy movement from voluntary BMPs to performance standards occurred for several reasons. First, given the incentive structure, voluntary programs were not effective in controlling pollution from dairies, even with high levels of cost sharing. Additionally, technologies have evolved over the period that have allowed monitoring the emissions from each dairy as a point source. The high recreational value of Lake Okeechobee created a political environment that allowed policy makers to consider regulation of agriculture. Finally, the number of dairies in the watershed is currently 34, a small enough number to not preclude monitoring each as a point source at a cost of approximately $5,000 per dairy per year.

Market factors, other than price supports for milk, did not play a strong role in creating or solving the pollution problem.

Environmental Problems Related to Agriculture

We now return to the four agriculturally related environmental problems introduced earlier, all of which involve market failures: (1) health risk to farm workers and consumers from use of pesticides; (2) conversion of wetlands and wildlife habitat to crop production; (3) groundwater pollution from nitrogen fertilizer, manure, and pesticides; and (4) pollution of surface water from soil, nutrients, and pesticides.

Health Risks from Pesticide Residues

Setting

While health risks from pesticide residues are not strictly an environmental problem, they are closely related to chemical use in agriculture and represent a market failure. Pesticide residues on foods are a market failure that was created by a shift in technology—increasing use of pesticides—coupled with an increasing preference by some consumers for pesticide-free produce. The relevant market failure is really an information market failure, since there is no way a consumer can distinguish produce that contains pesticide residues from produce that does not. It should be noted that the relevant market failure is not that producers are using pesticides known to cause human health problems—pesticides that constitute an unacceptable risk to health are banned or restricted by the EPA. The relevant market failure occurs because some consumers would be willing to pay more for produce with lower levels of pesticide residues than others, but producers could not sell the pesticide-free produce at a premium price because it would be indistinguishable from produce with pesticide residues.

Changes in the 1980s

Technology. The main relevant changes in technology have been the policy-induced development of pesticides that break down more rapidly in the environment and improvement in residue-analysis technology that reduces the cost of monitoring produce for pesticide residues.

Policies. The reauthorization of FIFRA requires a faster timetable for reregistering pesticides approved under less stringent testing regimes. Some states, such as California, have set stricter tolerances for pesticide residues on foods. Also, California has required a warning if the product contains a known carcinogen or reproductive toxin.

Markets. The greatest change in incentives faced by farmers has occurred because of changes in markets. Markets in certain states, including California, are evolving to provide consumers with a choice between produce that is certified to be free of pesticides and uncertified produce. Once such a market arises, the market failure ceases to exist because a price differential will arise that reflects consumers' preferences for pesticide-free produce, and farmers will respond to this differential by altering their production techniques if it is profitable to do so. Federal certification of organic produce in the current farm bill will support this trend. Another change has occurred in intermediate markets. The alar scare led most baby-food manufacturers to stop buying apples that had been treated with alar. This has established a trend, with many baby-food producers severely limiting the pesticides their growers can use.

Information. Information is a mixed bag for the health effects of pesticide residues. There is no doubt that more information exists now than ten years ago, and that at least in states like California a consumer is more informed about the pesticide content of foods. It is difficult to assess the net effect that information has had, however, because much of it has been conflicting and has been released in a highly sensationalized manner. In some markets, especially California, many consumers may be suffering from information overload and may be unable to distinguish significant health risks from insignificant risks.

Assessment

The evolution that has occurred or is occurring in markets to allow the consumer to choose between different levels of pesticide residue—different levels of perceived risk, really—has arisen because of changes in technology and the perception by retailers that money could be made by responding to consumers' demands for products differentiated on the basis of risk. Whether or not consumers' preferences for pesticide-free produce are actually strong enough to support risk-differentiated products remains to be seen. The important point is that decisions about whether to produce or consume pesticide-free produce are becoming internal to a well-developed market and are no longer externalities.

Conversion of Wetlands and Wildlife Habitat to Cropland

Setting

The conversion of wetlands and wildlife habitat to cropland is a classic market failure in which the costs to the farmer of converting the land to cropland do not include the costs imposed on society of reduced wildlife populations and reduced ecological services provided by the land. During the 1970s, when agricultural market and land prices were unusually high because of high export demand, large quantities of fragile grasslands in the High Plains and Mountain States were converted to crop production. At the same time, wetlands in the Northern Plains, the Mississippi Basin, and the Southeast were drained to support crop production.

The conversion of wetlands and wildlife habitat is not as simple an issue as pesticide residues on foods. There is no spatial element involved in the consumption of pesticide residues, though there is for pesticide use. A person ingesting a toxic chemical in California has basically the same reaction as someone ingesting the chemical in Florida. There is a strong spatial element with wetlands and wildlife habitat, however, with the prairie potholes in North Dakota providing a very different type of environmental service than, say, saltwater marshes in North Carolina. Conversion pressures also vary spatially. Instead of analyzing this category spatially, however, for the present purposes, it is more informative to divide the services provided by wetlands and wildlife habitat into three categories in terms of the degree of market failure involved.

The first category involves the harvest or sale of the right to harvest game species such as deer or pheasant where breeding and harvesting occur mainly on the farmer's land. For this environmental service, farmers have strong economic incentives to act in the interests of society, and the degree of market failure is slight or nonexistent and has been dealt with for a long time with the market innovation of fee hunting. The second category includes the production of game species that are not harvested on the farmer's farm, such as ducks raised in the prairie potholes in North Dakota and harvested in Texas. Here we have a genuine market failure given the high transactions costs involved in bargaining between hunters and waterfowl producers. The final category includes the production of nongame plant and animal species that have ecological, not market, value and the wide range of ecological services provides by wetlands. For this final category, the market failure is quite severe because the environmental services provided are somewhat vague, uncertain, and highly diffused throughout society.

Changes in the 1980s

Technology. Changes in technology include advances in the field of wetlands restoration and advances in land satellite imagery processing that have made it easier to construct and monitor a national wetlands inventory.

Policies. Policies protecting wetlands were strengthened in the 1980s, including increased enforcement of Section 404 of the Clean Water Act, the swampbuster restrictions in the FSA, and the eligibility for wetlands in the CRP. In addition, many states, such as Minnesota, moved to protect wetlands.

Markets. There were many significant changes in markets, including the rapid growth in the activity of private land trusts such as the Nature Conservancy and Duck's Unlimited. These groups acquired land through purchase or bequest and bought restrictive easements from land owners to try and protect fragile and valuable ecosystems. Duck's Unlimited, in particular, has concentrated on acquiring wetlands that are important breeding grounds for ducks.

Information. The main changes in information have been increased knowledge about the value of wetlands and other fragile lands, and better information on the location and conversion of wetlands given advances in land satellite image processing and geographic information systems. Advances in image-processing technologies have reduced the costs of monitoring and enforcing wetlands protection programs.

Assessment

Institutional innovations, in particular the growth of the private land trusts, have been important contributors in reducing the market failure involved in converting land of ecological value to cropland at a time of reduced federal acquisition of important lands. Given free-rider considerations, however, land trusts cannot be expected to eliminate the market failure nor can the swampbuster program, given that its teeth are dependent on the attractiveness of federal farm subsidies and Heimlich's finding of a less-than-perfect correspondence between areas where the swampbuster program will be effective and the location of valuable wetlands. While strides were made in the 1980s to protect valuable ecosystems, market failures remain, particularly for the production of nongame species and other nonmarket environmental services.

Groundwater Pollution from Agricultural Chemicals

Setting

Pollution of groundwater from agricultural chemicals, mainly nitrates and herbicides, was one of the most discussed agriculturally related environmental problems of the 1980s. It is a very complex problem, characterized by tremendous spatial variability in chemical use and groundwater vulnerability. There are two types of market failure with this problem: a classic externality, in which the environmental costs of chemical use are at least partially borne by off-farm users of the water; and an information market failure, given the limited information we have about the extent of contamination of private groundwater wells, uncertainty about the fate and transport of chemicals to and through groundwater, and uncertainty about the actual health risks from nitrates and pesticides.

Like the wetlands and wildlife habitat case, the degree of market failure is highly variable spatially. In areas where groundwater is protected by a clay lens or other impermeable barrier, agricultural chemical use may not cause any groundwater degradation. In areas where the relevant aquifer underlies the farm and there is little groundwater movement, the costs of chemical infiltration are fully borne by the farmer in the form of health risk to the family. In the first two cases, there is no externality, though there may be an information market failure if the farmer is not aware of the contamination or the risks. Finally, there is a market failure if chemicals used on the farmer's land lead to pollution of groundwater off the farm site. This would occur if the aquifer is larger than the farm (as is usually the case), if there are groundwater/surface-water interactions, or if there is a Karst condition, where chemicals reaching groundwater may move large distances in short periods of time.

Changes in the 1980s

Technology. The main relevant change in technology was the increased availability and use of gas chromatography and mass spectrometry, which allowed the detection of minute quantities of organic compounds, such as pesticides. Other important changes include the development of herbicides that break down more rapidly in the environment and that are less prone to leaching into groundwater. Relevant alternative farm practices include wellhead protection zones and appropriate use of chemigation equipment.

Policies. There was little change in federal groundwater policy other than stricter fate and transport testing of new pesticides and a faster timetable for testing old pesticides. Many federal groundwater bills were proposed, but none were passed. Most of the policy changes occurred at the state level. These state responses range from research and testing programs in states such as Iowa, to restriction of practices in nitrogen-sensitive areas in Nebraska, to regulation of chemigation equipment, to Connecticut's potable drinking water law and California's Proposition 65 (Wise and Johnson; Batie and Diebel).

Markets. Several market changes occurred, including the increased use of returnable or reusable pesticide containers. Perhaps one of the most important market evolutions is the increasing requirement of well tests by purchasers of farmland and by mortgagors prior to sale. As this practice becomes more widespread, the price of farmland may become as dependent on water quality as on soil quality. The linkage between the price of farmland and water quality would internalize some of the external costs of chemical use in situations where the quality of the groundwater on a farm was highly dependent on surface application of chemicals. This would not be the case in Karst situations.

Information. Information, and the lack thereof, has been a major factor in the evolution of the groundwater problem in the 1980s. Very little was, or is, known about the extent of contamination of drinking water from agricultural activities. A lot of monitoring efforts occurred in the 1980s, including EPA's survey of 1,500 private wells. While the EPA survey found pesticides from agricultural activities in only 1.2% of the test wells (Reichelderfer 1991), the spatial variability of the groundwater resource renders national-level assessments of groundwater quality almost valueless. I doubt people who live in regions of Iowa in which a significant percentage of private wells have been found to be contaminated by atrazine find EPA's results very reassuring. EPA did, however, find elevated nitrate levels in a significant percentage of its test wells. The linkage between elevated nitrates and human health is highly uncertain, however, except in the infrequent occurrence of Blue Baby Syndrome.

One fact that has emerged from the well tests is that in many instances, groundwater contamination from pesticides may be linked to accidental spills, faulty chemigation equipment, mixing and loading sites, and container-disposal sites.

Assessment

Agricultural chemical pollution of groundwater is such a complex and spatially variable issue that it is difficult to reach a generalized assessment. In many situations, farmers have incentives to use chemicals in ways that limit their infiltration into groundwater. Surveys of farmers cited in Reichelderfer (1990) bear out farmer family health concerns. This is reassuring and indicates that in many cases, information and technical assistance may go a long way towards solving groundwater problems that arise from normal application of chemicals. Another trend will be the conversion of many nonpoint sources of agricultural chemicals into regulated point sources. This trend is already occurring at the state level, with increasing requirements for technology-based standards for commercial mixing and loading sites, and increasing restrictions on the use of disposable pesticide containers. Finally, for highly sensitive areas, particularly Karst areas where surface use can contaminate groundwater many miles away, there will probably be increasing restrictions on surface activities.

Surface-Water Pollution from Agricultural Chemicals and Sediment

Surface-water pollution is a classic market failure. The costs of pollution are external to a farmer's decisions and are borne by downstream users of the water. In the case of major rivers, such as the Mississippi, the costs of the pollution may be felt one thousand or more miles from their source.

The nature of the problem varies spatially, though it is probably not as spatially variable as groundwater pollution. The eastern U.S. and eastern Washington State are most prone to problems from sediment pollution. The Southwest has problems with salinity. Surface-water pollution from pesticides can occur anywhere but is especially a problem in the Southeast, given the high rainfall and high use rates.

Changes in the 1980s

Technologies. The relevant technologies are mainly BMPs, most of which were developed prior to the 1980s. There was also widespread adoption of limited tillage for corn and the growing availability of pesticides that break down more rapidly in the environment.

Policies. The main policies are technical assistance and cost sharing for BMPs, and the CRP and the sodbuster restrictions from the FSA. California made it easier for private citizens to sue over damages to potential sources of drinking water (Phipps, Allen, and Caswell). There was also an increased movement toward treating animal confinement operations as point sources of pollution.

Markets. None.

Information. The National Resources Inventories (NRI) have helped to identify those regions of the country that are vulnerable to soil erosion. Improvements in fate and transport modeling have helped to link farm-level practices with downstream pollution.

Assessment

Surface-water pollution from agricultural chemicals and sediment was a vexing problem in the 1980s and remains one in the 1990s. Information from the NRI has resulted in improved targeting of soil conservation programs. The CRP has also resulted in a significant reduction in soil erosion but, until recently, was not focused on reducing surface water quality problems.

The degree of market failure with surface-water pollution and the usually high number of polluters make it difficult for markets or policies to evolve to the point where they can deal effectively with the problem.

Conclusion

For certain important agriculturally related environmental problems—health risk from pesticide residues on foods, preservation of wetlands and wildlife habitat for the production of game species, and certain groundwater quality problems where the pollution costs are at least partially borne by the farmer—changes in technology, policies, markets, and information in the 1980s have acted to lessen or eliminate the problem.

For other environmental problems—especially the preservation of fragile ecosystems that do not produce game species, groundwater pollution in Karst and other vulnerable areas, and surface-water pollution from agricultural chemicals and sediment—we still have a long way to go before effective solutions are found.

Based on experience from the 1980s, the following scenario seems reasonable for these most vexing problems. In situations where there is a high-valued resource and a small number of polluters, like the Lake Okeechobee case, regulations that mandate use of best available technologies and other forms of point-source pollution control will be used with increasing frequency. This situation will apply also to feedlots, mixing and loading and container-disposal sites for pesticides, and some Karst areas.

In cases where the resource has a high value but there are a large number of spatially dispersed polluters (e.g., dairies in the lower Susquehanna River drainage that feeds into the Chesapeake Bay), the costs of monitoring and enforcement are currently too high to recommend point-source regulations. It is likely that voluntary BMPs will be continued with a mix of regulated best available technologies for large operations.

For still other cases, including most nonpoint-source pollution of surface and groundwater, we will see continued use of voluntary technical assistance and cost sharing until information and technologies evolve to such a point as to make other policy or market alternatives feasible.

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