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Agricultural Externalities and Environmental Policy: Re-Emergence of an Old Issue

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Abstract

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Agricultural production in the United States has an off-farm environmental impact. This paper examines the impact of agricultural externalities on U.S. water resources. Also discussed are policy options for controlling agricultural contamination, issues relevant to these policy options, and an agenda for further economic research.

I - Introduction

There has been a great deal of public interest in recent months in the problem of environmental contamination from agricultural chemicals and farmland runoff. The recently enacted Water Quality Act of 1987 [12] for the first time places major policy emphasis on controlling agricultural nonpoint source pollution. Numerous bills have been introduced in the current session of Congress to address the issue of groundwater contamination from agricultural pesticides, herbicides and nitrates. The EPA and USDA have, in the past few months, issued major policy statements on protection of groundwater and surface water supplies from contamination from agricultural residuals. The implications of these policy statements have yet to be fully determined, but American agriculture can be expected to undergo changes in production options as input choices, tillage practices, and chemical use patterns are restricted or controlled.

None of this interest in the problem of agricultural chemical contamination is new. It has been more than 25 years since Rachel Carson, in Silent Spring, called attention to the environmental consequences of unrestricted pesticide use. Nonpoint source runoff has been recognized for years as a major source of surface water pollution. Several factors have contributed to the recent increase in attention given to this problem. One has been the increased use of agricultural chemicals in crop production. Nitrogen fertilizer use has more than doubled since 1960; application rates of fertilizers tripled between 1960 and 1985 [14]. At the same time as chemical use on cropland increased, we have had some success controlling point sources of pollution through the construction of municipal and industrial treatment plants. Thus the relative importance of agricultural nonpoint source pollution in the total water quality picture has grown.[1] Finally, discoveries of groundwater contamination in the late 1970's and early 1980's dispelled the commonly held view that groundwater was protected from chemical contamination by chemical degradation and impervious layers of rock, soil and clay. Continuing studies by EPA, USDA and others have shown that the problem of contamination of groundwater by agricultural residuals to be much more widespread than was thought a decade ago.

Interest in this area is bound to increase, both within the agricultural community and beyond. Implementation of the nonpoint source provisions of the Water Quality Act may lead to voluntary or even mandatory controls of cropping patterns and tillage practices on large numbers of farms. The 'cross-compliance' provisions of the 1985 Food Security Act will, in the early 1990's,

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[1] "Nonpoint sources [of water pollution] appear to be increasingly important contributors to use impairment. Intensified data collection efforts are certainly a factor in explaining their dominance. Another explanation may be that nonpoint source impacts are becoming more evident as point sources come increasingly under control." [16] See also [9].

require farmers on highly erodible land to prepare and implement conservation plans. Emerging groundwater legislation and reregistration of pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) could result in the cancellation of widely used agricultural chemicals.

This movement towards new public policy initiatives on agricultural pollution is of concern to the agricultural sector and agricultural economists because much of the impetus for change is coming from outside the traditional agricultural community. Most of the environmental programs and policies in question arise from legislation enacted outside of farm policy, and the role of USDA in these programs is secondary to other Federal agencies (viz EPA, the Interior Department, etc.) Unlike more traditional agricultural resource conservation issues (e.g. soil and water conservation) these policy initiatives are directed not at maintaining agricultural productivity, controlling surpluses, or maintaining farm income, but are instead the result of a much wider array of concerns, such as human health, environmental preservation, and resource amenity values. As such, the emerging environmental legislation and policy can be viewed as set of external constraints on the farm sector, rather than an integral part of farm policy. The consequences of these new and prospective environmental programs and policies for input use, commodity program crops, farm structure and farm income have yet to be clearly determined. Thus a need is arising for agricultural economists to examine the linkages between environmental policy regarding agricultural externalities and the structure, conduct, and economic performance of the farm sector.

This paper presents an overview of the scope, extent, and economic implications of agricultural externalities and the relationships between environmental policy and the farm sector. The options for controlling these externalities are discussed, along with a set of pertinent issues which will affect the economic analysis of environmental policies towards these externalities. A research agenda is proposed, along with some general conclusions about the role agricultural economics can play in integrating environmental concerns into the analysis of agricultural production.

II - The Scope of Contamination from Agricultural Residuals

Agricultural production can have many off-farm environmental impacts. The primary externality arises when agricultural chemicals or soil particles from cultivated lands are transported into surface water or groundwater supplies via leaching, rainwater runoff, or soil erosion. Subsequent ecological reactions and transformation of the contaminants in the environment have a wide array of adverse ecological impacts. The environmental effects of these residuals are well documented[2], and will only be briefly summarized here.

The presence in groundwater and surface water of pesticides, herbicides and other agricultural chemicals exposes humans to potentially harmful substances in their drinking water. Pesticides can also be damaging to commercially and recreationally valuable freshwater and marine fisheries. Sediment runoff from cropland increases turbidity of surface water, which is harmful to aquatic vegetation and disruptive to the food chain. Sediment detached from topsoil and transported to surface water by soil erosion also contributes to nutrient enrichment and contamination from toxic chemicals by carrying attached nitrogen, phosphorus and pesticides. Some general estimates are available of the magnitude of the costs of contamination from agricultural residuals. A summary of some recent findings is presented in Table 1. For more details the reader is referred to the original papers.

III - Options for Controlling Agricultural Externalities

A variety of options are available for controlling agricultural externalities. We have had in place for more than fifty years many Federal soil and water conservation programs for the farm sector, including traditional conservation measures such as set-asides, technical and financial assistance to farmers for structural and non-structural erosion control measures, and so forth. However, the types of soil conservation programs promoted by the USDA have not always been entirely consistent with the reduction of off-farm environmental damages. The emphasis of Federal soil erosion programs has traditionally focused on protecting soil quality and farmland productivity, not reducing the off-farm consequences of transported sediment. USDA studies [7, 10] indicate that more directly targeting soil erosion control programs with off-farm consequences as well as soil productivity in mind could increase the net economic benefits of these programs. Partly as a result of these studies, USDA is beginning to re-think the way soil conservation programs are carried out. The Soil Conservation Service is increasing emphasis on environmental protection and water quality enhancement as program goals. New training procedures for field personnel and extension programs are being developed to orient SCS field activities towards controlling agricultural water pollution. Future application of soil and water conservation measures, including structural solutions (terraces, sod waterways) and 'best management practices' (such as alternative tillage, crop rotations, and nutrient management schemes) may be targeted more at controlling nonpoint

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[2] See U.S. EPA [17] for a summary of groundwater pollution, and Clark, et. al. [1] for an overview of surface water pollution from soil erosion.

source pollution and designed with the aim of protecting both surface and groundwater resources.

We are also seeing a great deal of interest expressed both inside USDA and elsewhere in using the Conservation Reserve Program established by the 1985 Food Security Act as a tool for controlling agricultural nonpoint source runoff. As of today, the majority of lands taken out of production under the CRP have been west of the Mississippi River. However, the lands identified by the Environmental Protection Agency as having the greatest surface water quality problems lie to the east of the Mississippi, particularly in the northeast. The eligibility rules for including land in the CRP have been extended beyond land which is 'highly erodible' to include filter strips around lakes and streams. Further modification of the eligibility rules have been proposed by EPA and others to further expand the bid pools to include land which, if taken out of production, would lead to a reduction in runoff of nutrients, sediments, and agricultural chemicals to surface water by providing buffer strips around environmentally sensitive waters, and to provide setbacks around wellhead areas for groundwater protection.

The FIFRA implementation process also offers a tool for controlling water pollution from agricultural sources. The re-registration process by which the active ingredients used in agricultural pesticides and herbicides must be approved for use by EPA could be used as a management tool to control use of highly leachable chemicals to enhance groundwater protection. EPA is moving, under its pesticides in groundwater management strategy to encourage the States to file 'Pesticide Management Plans', with the implied threat that reauthorization of certain agricultural chemicals under FIFRA may be conditioned on such plans being in place.[3]

IV - Issues in Agricultural Externality Policy

Several issues have emerged in the debate over environmental policy regarding agricultural externalities. How agricultural economists can contribute to the debate over appropriate policy instruments is affected by our responses to these issues. While a full exploration of all the relevant concerns is beyond the scope of this paper, several of the more important factors facing environmental economists and public policy officials may be identified. Among these are the following:

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[3] From remarks presented at an EPA briefing on the proposed pesticides in groundwater strategy, Washington DC, November 27, 1987.

o Prevention vs. cleanup as national goals of environmental policy;
o The meaning and desirability of environmental quality standards;
o Voluntary vs. mandatory controls;
o The relative roles of the Federal agencies, States, and local governments.

In an ideal world, environmental externalities would be fully internalized by a set of Pigouvian taxes, and the full social costs of agricultural activity (including off-farm costs) would be realized. However, the nonpoint source and public goods nature of the pollution problem and the economic and fiscal realities we face make difficult resource allocation decisions necessary. Much of the controversy surrounding proposed groundwater legislation, for example has to do with the appropriate goals of Federal policy. One sentiment holds that what is needed is a broad policy statement similar to the language of the Clean Water Act [11], which set a goal of restoration of navigable waters to swimmable quality and elimination of pollutant discharges. On the other hand, others argue that since cleanup of contaminated groundwater is extremely expensive, a more cost-effective approach would be to prevent further contamination to protect the resources.

A related issue for the policy process to consider is the level of protection to be achieved. "Non-degradation" has become a consistent rallying point on the part of some of the interested parties: a goal should be set, it is asserted, that all water resources should be protected from further pollution regardless of current condition. This is in conflict with EPA strategies (at least as regards groundwater resources) of differential protection: allocating protection and cleanup activities to preserve and enhance those resources currently or potentially used for human activity (drinking water, recreation, etc.), and affording relatively less protection to waters currently contaminated which are not used for human or agricultural consumption.

A similar debate is continuing over the definition of resource quality standards. With respect to surface waters, environmental standards have been primarily technology-driven, at least as regards point sources. The goal has been to move from primary treatment to secondary and tertiary treatment via application of best practical technology or, ultimately, best available technology. When dealing with agricultural pollution, however, the choice of standard is much less clear. The pervasive nonpoint nature of the surface water contamination problem argues against simple technology-based control standards: in the words of one former EPA official "We've pushed technology about as far as it's going to take us." Rather, control of agricultural nonpoint source pollution is likely to involve input controls and adoption of alternative tillage and cropping practices rather than application of well defined technology as was the case with point sources. This makes the economic analysis of alternative management strategies difficult, because the relationship between on-farm activities and off-farm environmental consequences is difficult to model, hard to quantify, and highly location-specific.

In the area of groundwater contamination the choice of appropriate quality standards is even more complex. The concern over groundwater contamination is driven by the health impacts of human exposure toxic chemicals and nitrates. However, the health effects are poorly understood, and no consensus exists over just what "safe" exposure levels are. While environmental scientists have models which purport to predict health impacts of such exposure, they are extraordinarily imprecise when dealing with low levels of exposure over a number of years, and in any event are somewhat suspect to the general public, which prefers (indeed, demands) assurances of no exposure, and thus no adverse health effects from drinking water. Environmental groups favor limitation of allowable pesticide concentrations in groundwater, for instance, to levels at which no adverse health effects are observed, instead of technologically or economically feasible levels. There is even a disparity in current laws regulating pesticides; a goal of "no unreasonable risk" of exposure to hazardous chemicals in drinking water legislation vs. the risk/benefit calculations mandated under FIFRA. Despite the efforts of economists and others to push the philosophy of risk/benefit analysis as a tool for making resource allocation decisions, a large portion of the non-technical audience simply will not accept "reasonable" exposure as an appropriate environmental goal, favoring instead more drastic measures to remove, rather than reduce, the risk of exposure.

Along with the controversy of just what the standards should be regarding environmental contamination from agricultural activity, an additional debate centers on the appropriate type of regulation and the institutional question of regulatory decision making. The first issue is whether or not to impose mandatory, regulation-based controls on agricultural activity to control pollution, or to rely upon voluntary action and compliance with guidelines as buttressed by market incentives and the "stick" of future regulatory action. Since agricultural pollution is primarily a nonpoint source problem, there has been great reluctance on the part of some at the Federal level to get involved in what is considered a local problem.

Particularly with respect to groundwater protection, environmental action implies implementation of land use controls. Since the vulnerability of water resources (both surface water and groundwater) to agricultural contamination depends on local hydrogeological, climate, cropping and soil characteristics it is difficult to see how uniform national regulatory standards could be effective in controlling a nonpoint source pollution problem. Rather, the argument is made that the design and implementation of nonpoint source surface water and groundwater pollution control programs should be placed at the state and local level, with only the most basic guidance from Washington in the form of general standards and technical assistance. This feeling is buttressed by the view that controlling nonpoint source pollution implies making decisions on land use and zoning that traditionally have been handled at the local level.

The attitude in Washington seems to be that to the greatest extent possible voluntary controls should be relied upon instead of mandatory, administered regulations to achieve nonpoint source pollution control goals. The policies emerging from USDA and EPA in the nonpoint pollution and groundwater protection areas clearly and strongly stress the need for voluntary compliance on the part of farmers, rather than a strict regulatory approach.[4] In both the implementation of the 1987 Water Quality Act nonpoint source provisions and in the recently announced pesticides in groundwater strategy the EPA regulatory approach has been to leave the design and implementation of pollution control and mitigation to state and local officials. Federal agencies will provide technical expertise, information, guidance and play a general oversight role relative to local actions in enacting and monitoring nonpoint source pollution controls, but will not be directly involved in establishing uniform national standards or prescribing definitive control measures (at least for the present). This is combined with a general reference point strategy, where maximum contaminant levels (MCL) are established, and emergency actions may be triggered (for example, cancellation of a particular pesticide) when ambient concentrations reach a particular level (for example, 50% of MCL). This is called the "yellow-light/red-light" approach. [15]

The counter argument against this decentralized strategy is that it may result in a hodgepodge of conflicting policies among various local, State and Federal jurisdictions regarding agricultural chemical use, nutrient applications and farming practices. For example, the pesticide industry is concerned that state-by-state regulation could result in 50 different standards on pesticide use in environmentally sensitive areas. A concern has also been raised that allowing states to set their own levels of allowable contamination and regulations regarding agricultural chemical use could result in less environmental protection than would be the case if strict Federal standards were imposed.[5] In response to this concern, current EPA policy, even under the differential protection strategy regarding groundwater, is to set minimum standards for contamination and ambient water

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[4] See [15] for further explanation.

[5] Senator Durenberger (R-MN) pressed EPA administrator Lee Thomas particularly forcefully on this point during hearings on EPA's role in groundwater protection this winter. The Senator's concern was that a lack of ambient water quality standards at the Federal level would permit local water quality in some areas to exceed recommended concentrations of toxic chemicals.

quality that the States could not relax; individual jurisdictions would be permitted to enact more stringent regulations, however, if they chose to.

V - Research Issues for Agricultural Economics

Several conclusions may be derived from this brief survey of agricultural contamination in the U.S. The first is that despite the sketchy nature of the damage estimates and the wide confidence intervals placed on the dollar values of economic losses, it appears that contamination of groundwater and surface water resources from agricultural residuals in the U.S. is extensive, and results in a considerable off-site economic cost.

A number of research issues remain to be addressed. While by no means exhaustive, several of the more important items on an agenda for agricultural economists interested in externality issues would include:

- Data availability and reliability;
- The linkages between on-farm commercial agriculture and off-farm environmental fates and consequences of agricultural residuals;
- The resulting impacts on the farm sector of environmental policy changes;
- The impacts of controlling agricultural externalities: the welfare effects of improvement in environmental quality.

Clearly, more refined and better estimates of damage are needed. At a national scale, however, we are unlikely to get very far in updating and revising our estimates without reorganizing, integrating, and gathering additional and much more comprehensive data; particularly on pesticide and fertilizer use and management practices at the national level. Despite the commendable effort put forth by EPA, RFF, and the USGS in compiling their data, the unavoidable necessity for manipulating, smoothing, caressing, and generally fiddling with the data that are available means that analysis is probably not supportable at the county level presently. Particularly troublesome is our lack of knowledge about the status of groundwater resources.

The data problem may become less troublesome in the coming years. As part of the nonpoint source (Section 319) provisions of 1987 Water Quality Act States will be required to submit to EPA an inventory of navigable waters subject to nonpoint source pollution problems. As the implementation of nonpoint source control programs and the monitoring of these programs proceeds our understanding of the nature and the scope of the nonpoint component of surface water pollution should improve. Similarly, within two years the EPA hopes to complete an extensive survey of private and public wells to determine the extent of contamination from pesticides.

One particularly critical research need for agricultural economists is to define, analyze, and begin to measure the linkages between off-farm environmental damages from agricultural pollution, alternative policies to control these externalities, and on-farm impacts of these policies. One area that should receive additional research is the relationship between farming practices, soil characteristics, hydrogeological factors, surface runoff, and groundwater contamination. If controlling nutrient loadings from soil erosion in lakes, streams and estuaries means keeping the soil on the land and reducing tillage to a minimum, for example, it may mean that farmers will apply more herbicides to control weeds or fertilizer to boost yields. This could increase the danger of leaching of nitrates and toxic chemicals into groundwater.

Consider for the moment one potential environmental policy: EPA has identified over 600 counties in 40 states where labeling may be required to restrict use of pesticides in habitat areas of endangered species. Removal of extensively used pesticides from productive use could have significant impacts on farmers in these areas, leading to possible changes in input mix and raising a troublesome set of regional comparative advantage and distributional issues. As of now, our models offer little guidance into the farm-sector affects of such policy shocks, especially in light of possible geographic and regional differences in the proposed restrictions.

In essence, we need to build into our farm sector economic models the capability of estimating the effect of external constraints placed on commercial agriculture by changes in environmental policy. This would entail simultaneously estimating the impacts on relative costs of affected factors (viz, pesticides), input mix, output, commodity program variables, farm income, and other structural variables (farm size, distribution, land use, and so forth). While a variety of models are available for estimating resource and policy impacts on U.S. agriculture (the Iowa State CARD model or USDA's FAPSIM, for example), many of the structural relationships in these models may have to be re-evaluated or alternative specifications imposed.

Our profession needs to estimate the off-farm consequences of environmental policy changes. The final goal would be to estimate a social cost function, which would reflect the fully internalized cost of agricultural externalities. Here, traditional economic (costs/benefit) analysis may play a more limited role. Of the current environmental legislation, only FIFRA encompasses a risk of exposure vs. benefit of use evaluation framework. Other legislation, such as the Endangered

Species Act, specifically prohibits the use of risk/benefit analysis as an analytic tool. The Delaney clause in the Safe Drinking Water Act specifically calls for a zero tolerance level of any proven carcinogen. Despite the efforts of economists to develop economic computations of the costs associated with health risks and the use by EPA of expected health impacts as a measure of environmental risk, the public at large remains highly skeptical of explicit risk vs benefit tradeoffs, especially in a situation where aggregate exposure levels, toxicity levels, and associated health impacts are uncertain or speculative.

When the issue is less one of human health impacts than one of general environmental quality, however, economic analysis may have a larger role to play in computing off-farm benefits of controlling agricultural externalities. There is a large and well developed body of literature and analytic techniques for valuing non-market environmental resources. Such considerations as existence values, option values, recreation values, and bequest values of environmental resources can be addressed using the techniques developed in recent years by the resource economics discipline.[6]

One final thought: if we assume that controlling agricultural pollution implies restricting chemical inputs and tillage practices, it follows that we as researchers should be giving some consideration to "alternative agriculture." Interest in low-input or sustainable agricultural systems could be expected to increase as farmers react to the changes which could be imposed on them in the coming years from recently enacted environmental legislation. As the nonpoint source control plans of the 1987 Water Quality Act and the cross-compliance provisions of the 1985 Food Security Act are implemented, commercial agriculture could undergo some shifts in production activity. If nothing else, those of us interested in environmental economics should be prepared to answer some fairly tough questions on the tradeoffs between alternative (higher cost) food production technologies and the economic benefits of improving environmental quality.

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[6] For example, Ribaudo [8] used a fishing participation model to estimate the economic valuation of enhanced sport fishing opportunities derived from reduction of nonpoint source pollution associated with the USDA's Conservation Reserve Program.

Table 1:
Extent and Cost of Agricultural Contamination

Problem	Effect	Extent	Damage Estimates
Soil Erosion and Surface Water Runoff:			
Nitrogen and Phosphorus dissolved in runoff, nitrogen attached to soil particles in runoff.	Eutrophication of lakes and streams. Damages to aquatic organisms. Recreational losses. Damages to commercial and recreational fisheries.	52 Percent of suspended sediment, 61 percent of nitrogen, and 52 percent of phosphorus discharge in freshwater systems derived from agricultural sources. [4] Forty eight of 99 watersheds were found to have excessive levels of at least one pollutant (Nitrogen, Phosphorus, Suspended Sediment) in freshwater systems [7]. In seventy eight coastal estuarine drainage areas, 58 systems showed significant shares of nutrient loadings from agriculture and/or high pesticide runoff from cropland.[3]	Estimated annual losses from soil erosion from all sources: between $4 and $15 billion per year; a "best estimate" of $7 billion. Damages associated with soil erosion form cropland estimated at $2 billion per year.[7]
Sediment in cropland runoff.	Siltation of waterways and storage reservoirs. Increased costs to municipal treatment and water supply systems. Damages to aquatic organisms.		
Toxic chemicals (pesticides and herbicides) in runoff.	Damages to commercial and recreation fishery resources. Possible human health effects.		
Groundwater Contamination:	Nitrogen applied to cropland leaches into groundwater, forming nitrates and nitrates: possible human health effects. Leaching of pesticides and herbicides into groundwater. Concern over carcinogens and other toxic elements to human and consumption, especially in drinking water.	Potential population exposed to contaminated drinking water: 50 million. 1,400 counties show potential groundwater contamination from pesticides and/or fertilizer use. [5]	Monitoring and avoidance costs placed at between $900 and 2.2 billion per year [5]. Does not include valuation of potential human health effects.

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