Chapter 5

Farmer Decisionmaking and Technical Assistance

CHAPTER HIGHLIGHTS

- People who make decisions about nutrient and pest management in agriculture include farmers, commercial applicators, and the individuals who advise them. A comprehensive approach to reducing agrichemical contamination of groundwater will consider the roles, opportunities, and constraints of all types of agrichemical applicators and advisors.
- Agricultural applicators handle fertilizers, general-use pesticides, and restricted-use pesticides (RUPs). EPA's applicator certification requirements solely apply to RUP applicators, and RUPs constitute only 20 percent of total agricultural pesticide volume used. EPA does not require States to train applicators, and certification requirements vary widely. Expanded Federal directives for applicator training may be needed to improve agrichemical management nationwide.
- Two of the four approaches to reducing agrichemical contamination of groundwater, *improved point-source controls* and *improved agrichemical efficacy and application draw* from a huger information base, employ well-established information sources, and are perceived to be less risky and easier to implement than *use-reduction* and *nonchemical* approaches.
- Farmers interested in use-reduction and nonchemical practices have noted that State Cooperative Extension Services (CESs) have provided inadequate information on these approaches. Such farmers seek information from other experienced fanners; these "farmer-to-farmer networks are playing important roles in disseminating information on more complex farming system changes.
- Farmers, or private applicators, are responsible for applying at least half of all agrichemicals in agriculture. Keeping records of the types, amounts, and locations of agrichemicals used would provide the means for farmers to quantify nutrient and pest management costs and evaluate new practices. Agrichemical recordkeeping may be the most important prerequisite to optimizing agrichemical rates used.
- Farmers' decisions are based on their fundamental objectives for farming. Although other social and environmental factors influence objective-setting, economic factors define what is financially possible for farmers, often forcing them to focus on the short term Institutional factors (e.g., commodity programs) influence farmers' willingness and ability to implement resource-protecting practices.
- Since most farmers hold off-farm jobs and may not have needed time or expertise, farmers could purchase advisory services that reduce their operations' adverse environmental impacts. Increasing services and improving commercial employees' environmental expertise would result in improved nutrient and pest management decisions.
- Decisionmaking for groundwater protection represents only one aspect of societal efforts to protect natural resources in agriculture. Programs that help farmers protect groundwater could fit into a broader research and extension strategy that aids farmer decisionmaking to protect natural resources overall.
- The range of assistance available to all types of agrichemical applicators will depend *on the local "mix"* of Federal, State, and local programs. Technical assistance opportunities also will be influenced by the degree of coordination among public-sector personnel and their commitment to natural resource protection in agriculture.

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Farmer Decisionmaking and Technical Assistance To Reduce Agrichemical Contamination of Groundwater

INTRODUCTION

Farmers use agrichemicals to save time and labor, increase productivity, and reduce the uncertainty and risk involved in obtaining consistent, desired yields. Groundwater contamination by agrichemicals, however, may occur when: 1) agrichemicals are mismanaged, regardless of the area's intrinsic hydrogeologic vulnerability; or 2) hydrogeologic vulnerability is so great that even proper management practices may not prevent groundwater entry by certain types of agrichemicals. Although a wide range of management practices, technologies, and cropping systems is available to reduce agrichemical contamination of groundwater, their adoption and use ultimately depend on decisions made by individual farmers. Thus, farmer decisionmaking is particularly important to consider when assessing the costs, feasibility, and effectiveness of management practices to reduce groundwater contamination.

Management changes to protect groundwater can be grouped into four approaches:

- agrichemical management to reduce point-source contamination (mixing, loading, storage and disposal practices);
- improved agrichemical application management (agrichemical selection, application rate, timing, method, and equipment);
- agrichemical use reduction; and
- use of nonchemical practices (biological and cultural).

Each of these approaches is associated with different constraints that will influence adoption by farmers. Regardless of the approach, however, farmers' selection and maintenance of groundwater-protecting practices will be a critical link in reducing agrichemical contamination of groundwater, whether this is done through voluntary, cross-compliance, or regulatory programs.

AGRICHEMICAL APPLICATORS IN THE AGRICULTURAL SECTOR

Today's agricultural production methods rely on agrichemical use, and a large but unknown number of individuals within the agricultural work force mix, apply, and dispose of agrichemical products. Farmers apply agrichemicals themselves or pay for custom application services. Thus, strategies to reduce groundwater contamination should consider the numbers, types, and roles of private and commercial agrichemica1 applicators, their relative contributions to agrichemical management overall, and their specific constraints and opportunities.

Agrichemical applicators area highly heterogeneous group and include part- and full-time farm operators, hired farmworkers, unpaid farmworkers, hired farm managers. and custom applicators (table 5-1). Agrichemical applicators differ in terms of occupational setting, business objectives, available resources, and management skills. Policies and program which address the different objectives, needs, and skills of all agrichemical applicator groups are more likely to result in improved agrichemical management and reduced groundwater contamination than policies that are generalized and uniformly applied.

General Categories

Classifying agrichemical applicators by group is useful in identifying specific constraints and opportunities to improve agrichemical management. Agricultural applicators handle three general categories of agrichemicals: 1) fertilizers; 2) general-use pesticides; and 3) restricted-use pesticides. Persons using

Table 5-1—Agrichemical Applicator Groups in the Agricultural Sector

Private agricultural sector	Commercial agricultural sector
Farm operators (full-time; part-time)	Independent custom applicators
Farmworkers (hired; unpaid)	Custom applicators employed by:
Farm managers employed by banks, real estate firms, etc.	Farmer cooperatives Franchised dealerships Independent dealerships Fertilizer plants with sales outlet Farm management service firms
Independent farm managers	
	Independent farm management consultants

SOURCE: Office of Technology Assessment, 1990.

fertilizers are typically not subject to applicator certification requirements. Persons using general-use pesticides are also not subject to certification requirements, except for commercial applicators in some States (table 5-2). All persons handling restricted-use pesticides (RUPs), however, must either be certified or under the direct supervision of a certified applicator (see box 5-A). Thus, RUP applicators are of three general types: 1) private certified; 2) commercial certified; and *3)* noncertified applicators under the direct supervision of a certified applicator.

Table 5-2—Agrichemical Categories and Applicator Certification Requirements

Type of applicator	Certification needed to apply		
	Fertilizers	General-use Pesticides	Restricted-use Pesticides
Private	No[a]	No	Yes
Commercial	No	Yes, in some States only	Yes

[a]An exception is Nebraska, where farmers in some Natural Resources Districts with documented groundwater contamination by nitrates are required to undergo training on fertilizer application procedures.

SOURCE: Office of Technology Assessment, 1990.

Private v. Commercial Applicators

Private agricultural applicators use or supervise the use of agrichemicals on property they own or rent, and they may apply agrichemicals on another grower's property without financial compensation as a way of trading personal services. Commercial applicators use or supervise the use of agrichemicals as a business service and are licensed or registered to conduct business in their States. Depending on their business volumes, commercial applicators are often responsible for applying agrichemicals over larger land areas than private applicators and are subject to more certification and reporting requirements. However, private applicators working on large farm operations may also apply agrichemicals over thousands of acres.

Overall, private applicators are responsible for applying at least half of all agrichemicals in agriculture, with commercial firms and contractors applying the remainder. Custom-applied fertilizer accounts for about 47 percent of the tonnage sold by bulk blend and fluid fertilizer plants, and 32 percent of the tonnage sold by retail outlets (56). About 40 percent of total farm expenditures for either commercial fertilizers or pesticides in 1986 were for custom applications, which included materials and application costs (158).

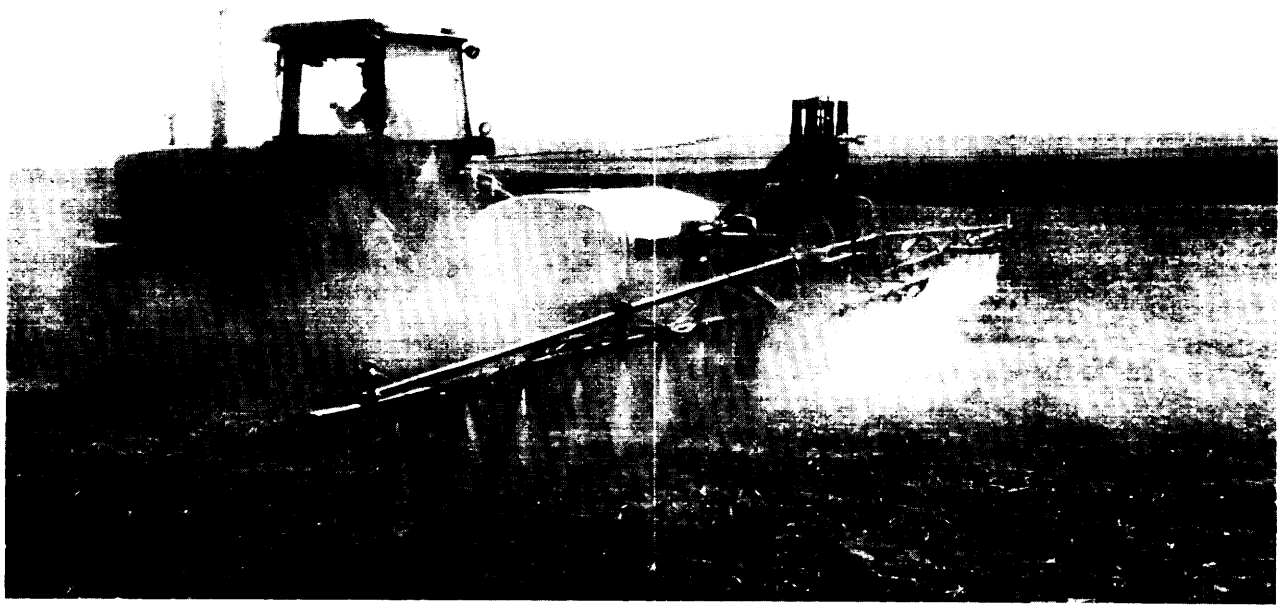


Photo credit: U.S. Department of Agriculture, Agricultural Research Service

EPA estimates that 2.3 million persons applied restricted-use pesticides in U.S. agriculture in 1988. This estimate does not include applicators of general-use pesticides or fertilizers.

Box 5-A—Pesticide Classification and Applicator Certification

The 1972 FIFRA amendments authorized EPA to set conditions for pesticide use through a two-tiered pesticide classification system. EPA classifies pesticides for general-use if it determines that the pesticide will not cause unreasonable adverse effects on human health or the environment if applied according to label directions or commonly recognized practice. EPA classifies pesticides for restricted-use if they may cause unreasonable adverse effects under such conditions.

FIFRA requires restricted-use pesticides (RUPs) to be applied only by persons who are: 1) certified as competent in handling pesticides, or 2) under direct supervision of a certified applicator (39). Persons using general-use pesticides need not be certified but they are legally required to follow pesticide label directions. For certain pesticides, some uses (but not all) may be classified as restricted, depending on the pesticide's acute toxicity and the site and purpose of use. States also have the authority to classify additional pesticides used within their borders as "restricted-use' or "limited-use."

The number of EPA-designated RUPs varies, depending on new products, new restrictions, and product cancellations. As of July 1988, EPA restricted 102 federally registered pesticides:

Type of pesticide	Number restricted as of July 1988	Percent total volume of RUPs used in 1987
Insecticide	54	10.6
Herbicide	11	7.4
Fumigant	11	[a]
Vertebrate control	11	[a]
Wood preservative	8	71.3
Fungicide	6	Use data not available
Other	1	[a]

[a]Collectively, 11 fumigants, 11 vertebrate controls (3 avicides and 8 rodenticides) and 1 molluscicide accounted for 10.6 percent of restricted-material volume.

SOURCE: U. S. Environmental Protection Agency, Office of Pesticide Programs, Certification and Training Branch, "Certification and Training Program, Update," 1989.

General-use pesticides constituted 80 percent of the estimated 2.5 billion pounds of active pesticide ingredients used in all sectors of the United States in 1987 (167). This total included 1.5 billion pounds of wood preservatives, sulfur, and disinfectants, and about 1 billion pounds of ''conventional" pesticides, U.S. agriculture used about 75 percent of all conventional pesticides that year, and RUPs constituted only about 19 percent of the volume of agricultural pesticides used. Because each State varies in the number of additional pesticides which are State-restricted, ' this percentage estimate may be low for some States.

Type of pesticide	Estimates of pounds used in 1987
Total "conventional" pesticides	1,085 million
Agricultural pesticides	815 million[a]
Maximum estimate for agricultural pesticides classified by EPA as RUPs	151 million[b]
Volume of agricultural pesticides not covered by EPA certification requirements	934 million

[a]SOURCE: U.S. Environmental Protection Agency, Office of Pesticide Programs, Economic Analysis Branch, Pesticide *Industry Sales and Usage: 1988 Market Estimates,* February 1990.

[b]EpA estimated that 526 million pounds of restricted-use materials were used in 1987, of which 71 percent were wood preservatives (167). Assuming that the remainder, or 29 percent, of restricted-use materials were pesticides ued in agriculture would yield 151 million pounds. Note that this is a maximum estimate, because RUPs used outside of agriculture would be included.

Thus, the major share of agricultural pesticides are not covered by Federal applicator certification requirements. Lack of coverage means that most pesticides can be applied by people who are not required to demonstrate their knowledge of pesticide hazards to a government agency. Although in practice many general-use pesticide applicators are certified, the low number of Federal restrictions requiring applicator certification reflects a low level of national commitment to supporting proper pesticide use. Although it is still possible for a certified applicator to mismanage pesticides, certified applicators are at least exposed to a State examination procedure that conveys the importance of proper management to the applicator. Stricter Federal applicator requirements applied to a greater number of pesticides would provide more incentives for proper management of pesticides in agriculture.

EPA is authorized to classify pesticides for restricted-use if they cause groundwater contamination, but some pesticides that have been found in groundwater have not been classified as restricted-use at the Federal level. In the absence of stricter Federal restrictions, States may act to protect groundwater resources by classifying for restricted use all pesticides found in groundwater. States could also require applicators to receive training on pesticide impacts and management methods to minimize groundwater contamination.

Certified v. Noncertified Applicators

The terms "certified" and "noncertified" refer only to RUP applicators. Certified applicators hold EPA-approved State certifications to apply RUPs by having demonstrated a standard level of competence in pesticide handling. Certified applicators also are allowed to supervise RUP use by noncertified applicators, who are typically employees. Private applicators fall under one certification category—agricultural pest control (12 1). Commercial applicators, on the other hand, can receive certification in at least 10 different categories:

- agricultural pest control (plant and animal);
- forest pest control;
- ornamental and turf pest control;
- seed treatment;
- aquatic pest control;
- right-of-way pest control;
- industrial, institutional, structural, and health-related pest control;
- public health pest control;
- regulatory pest control; and
- demonstration and research pest control.

Approximately 1.27 million applicators held valid certifications in 1988; 1 million of these were private certifications (all agricultural) and 254,000 were commercial, of which 72,000 were for agricultural pest control (table 5-3). The EPA estimates that each certified private applicator supervises one noncertified applicator; each certified commercial agricultural applicator supervises three to four noncertified applicators (61). Thus, an estimated 50 to 55 percent of all agricultural RUP applicators were noncertified in 1988 (121).

No estimates exist for the number of persons applying general-use pesticides. Many farmers apply both general-use and restricted-use pesticides, although some farmers avoid using RUPs, which eliminates the need to be certified. Differences among agrichemical applicator groups with respect to certification, supervision, and private v. commercial work setting imply that some applicators are more experienced or better prepared to manage agrichemicals than others. Poorly trained, inexperienced, or hurried applicators are more likely to mismanage agrichemicals. Agrichemical mismanagement is the intentional or unintentional mishandling of agrichemicals, including improper mixing, inappropriate timing of application, use of excess application rates, mixing or disposal in areas at high risk of contaminating water sources, application under inappropriate weather conditions, and improper disposal. Applicator certification and training programs can help applicators manage agrichemicals safely and properly, but current programs primarily assist RUP users rather than applicators of general-use pesticides or fertilizers.

Table 5-3-Number of Restricted-use Pesticide Applicator Certifications and Estimated Number of Potential Noncertified Applicators, 1988

Applicator category	Number of certifications
Commercial	250,268
Agricultural	72,350
Plant pest control	63,832
Animal pest control	8,968
Non-agricultural	177,918
Private (essentially all agricultural)[a]	1,019,978
Total certifications[b]	1,270,246
Potential noncertified applicators (includes commercial and private):	
Agricultural	1,300,000
Non-agricultural	1,000,000

[a]National figures compiled from reported numbers Of State certifications, personal communication with Charles Reese, Chief, Certification and Training Branch, Office of Pesticide Programs, U.S. Environmental Protection Agency, Oct. 24, 1989.
[b]EPA estimates that about one-third of all certified individuals hold both private and commercial certifications (personal communication, Yvette Hopkins, Economic Analysis Branch, Office of Pesticide Programs, U.S. Environmental Protection Agency, Nov. 29, 1989).
[c]From "Certification and Training Program," unpublished briefing outline prepared for Linda Fisher, Office of Pesticide Programs, by Certification and Training Branch, Office of Pesticide Programs, U.S. Environmental Protection Agency, June 22, 1989.

SOURCE: Office of Technology Assessment, 1990.

Private Applicator Groups

Private agricultural applicators comprise farm operators, who manage their own farm businesses, and farmworkers, who work for farm operators and may be assigned to apply fertilizers or pesticides as part of their job responsibilities. Of the 7.7 million people employed on farms either full-time, part-time, or seasonally in 1987 (table 5-4), EPA estimated that approximately one-fourth of the total used restricted-use pesticides that year (61).[1] However, the proportion of private agricultural workers using all types of agrichemicals, including fertilizers and general-use pesticides, is probably higher.

[1]In 1988, EPA began compiling national figures from State reports on the numbers of certified restricted-use pesticide applicators. Based on certifications, the number of individuals using restricted-use pesticides in agriculture that year was estimated at 2.3 million (121).

Table 5-4-Numbers of Farm Operators, Hired Farmworkers, and Unpaid Farmworkers, 1987a

Group	Number
Farm operators	2,753,000[b]
Hired farmworkers	2,463,000
Unpaid farmworkers	3,559,000[d]
Total	7,687,000

[a]These numbers do not include estimates of foreign nationals or illegal aliens who worked on farms in the United States in 1987. No reliable estimates of the numbers of illegal aliens exist, although one USDA estimate of Illegal aliens in the early 1980s was 10 to 15 percent of all hired farmworkers (from 'Trends in Farm Labor," *Agricultural Outlook*, U.S. Department of Agriculture, Economic Research Service, September 1984).
[b]The number of farm operators is slightly higher than the National Agricultural Statistics Service (NASS) estimate for the number of farms (2,1 73,000), because the NASS definition of a farm permits only one operator to be counted per farm, About 24 percent of farm operator households have more than one operator. The number of farm operator households (2,1 78,000) in 1987 is similar to the number of farms (from table 532, *Agricultural Statistics*, U.S. Department of Agriculture, 1988).
[@]fall hired farmworkers, 1.6 million had 25 or more days of hired farmwork.
[d]Of all unpaid farmworkers, 1.2 million had 25 or more days of farmwork.
[e]Total number of Individuals in the agricultural work force is less than the sum of farm operators, hired farmworkers, and unpaid farmworkers, because some individuals are included in more than one group.

SOURCE: Compiled from Victor J. Oliveira and E. Jane Cox, *The Agricultural Work Force of 1987: A Statistic/ Profile*, U.S. Department of Agriculture, Economic Research Service, May 1989.

Table 5-5—Primary Employment Status of Farm Operators, 1987

	Farm operators	
Primary employment status	Thousands	Percent
In labor force	2,298	83.5%
Operating a farm	1,183	43.0
Non-farmworker	1,107	36.9
Hired farmworker	57	2.1
Unpaid farmworker	30	1.1
Unemployed	12	0.4
Not in labor force	455	16.50/0
Keeping house	208	7.6
Attending school	60	2.2
Other	187	6.8
Total farm operators	2,753	100.0

SOURCE: Victor J. Oliveira and E. Jane Cox, *The Agricultural Work Force of* 1987: *A Statistical Profile*, table 14, U.S. Department of Agriculture Economic Research Service, May 1989.

Farm Operators

Farm operators are individuals directly responsible for a farm's routine purchasing, marketing, and management decisions, and they can be owners, tenants, or corporate managers. The total number of farm operators in the United States in 1987 was estimated at 2.7 million (153). That year, only 43 percent of all farm operators reported their primary employment status as operating a farm, with 37 percent reporting primary employment in off-farm jobs (table 5-5) (105). Operators of farms in small and part-time ''sales classes' are more numerous than moderate- and large-size farm operators, although they account for only about one-fifth of all farm products sold (table 5-6), Small and part-time farm operators are more likely to hold off-farm jobs than large-farm operators, since farms in smaller sales classes often provide lower net incomes. Numbers of farm operators are decreasing due to the overall decline in farm numbers, a trend reviewed in a previous OTA report (144).

The number of farm operators who use agrichemicals can be estimated from USDAs Farm Costs and Returns Survey,[2] which gives the number of farms reporting expenditures on fertilizers and pesticides (assuming at least one farm operator per farm). An estimated 57 percent of all farms in 1986 had pesticide expenditures, and 75 percent had fertilizer expenditures (158). However, since farm operators of commercial-sized crop farms are more likely to use agrichemicals than operators of livestock operations, organic farms, and small hobby farms (all of which were included in the survey), these percentages would be higher if they were based on commercial-sized crop farms only. Percentages of commercial-sized crop farms using certain types of agrichemicals (e.g., herbicides) are likely to be higher--+. g., at least 95 percent of all corn, cotton, and soybean acres in the United States had been treated with herbicide in 1987 (107).

Regardless of the type of farm, farm operators and managers are more likely than farmworkers to select and purchase agrichemicals applied, because they make the financial decisions for their farms. In the case of larger farms owned by more than one operator, several individuals may be involved in making decisions about agrichemical use and associated changes in farm practices. Farm size and ownership arrangements thus could affect farm operators' abilities to respond to environmental concerns. A sole proprietor of a farm business, for example, would probably have more autonomy in making farm management changes to reduce groundwater contamination than individual partners in a

[2]USDA and the States' Departments of Agriculture coordinate the Farm Costs and Returns Survey, conducted in February-March of each year on a sample of 24,000 to 26,000 farmers, who respond on a voluntary basis. Responses from the sample are statistically expanded to represent national totals. The survey collects information on costs of production, earnings, debts and assets, and some production practices.

Table 5-&Distribution of Farms[a] by Sales Class[b] and Percent of Total Cash Receipts by Sales Class, 1987[c]

Sales class	Value of farm products sold	Number of farms	Percent of all farms	Percent of total cash receipts
Small, part-time	<$20,000	1,380,000	63.4%	5.2%0
Part-time	$20,000-99,999	495,000	22.8	17.3
Moderate	$100,000-249,999	201,000	9.2	22.0
Large	$250,000-499,999	71,000	3.2	17.9
Very large	2$500,000	29,000	1.3	37.5
Total	—	2,176,000	100.0	100.0

[a]A farm is defined as an establishment that sold or would normally have sold $1,000 Or more Of agricultural products during the year.
[b]Categorization of farms into sales classes is based on the gross market value of all agricultual products of farms that are sold, placed under government loan programs, or otherwise removed from the farm. It excludes the value of direct government payments, farm-related income, and nonmoney income.
[c]Sales class distributions for 1987 are based on the 1982 Census of Agriculture (U.S. Department Of commerce, Bureau of the Census, *Statistical Abstract of the United States,* December 1988).

SOURCE: Compiled from U.S. Department of Agriculture, Economic Research Service, *Economic Indicators of the Farm Sector, National Financial Summary, 1987,* tables 28 and 31, 1988.

farm partnership. Trends in the changing structure of agriculture and their farm impacts will also influence farm operators' decisions on agrichemical use and management (see box 5-B).

Farmworkers

Farmworkers may be either hired or unpaid, and as a group they vary greatly in demographic features, employment status, and earnings. Hired farmworkers are persons 14 years or older who earn money by doing farm work at any time during the year, even for one day. The number of hired farmworkers in 1987 was estimated at 2.5 million (table 5-4). Only about 18 percent of all hired farmworkers worked for 250 days or more, and about 35 percent worked fewer than 25 days during the year (105). Hired farmworkers constitute a greater percentage of total farm employment than they did 10 years ago, because unpaid family labor has declined as a proportion of the total agricultural labor force. In the last 10 years, numbers of hired farmworkers has remained steady, with an increasing proportion of hired farmworkers working more days per year.

Unpaid farmworkers do not receive cash payments for farm work but may receive a token allowance, room and board, or payment-in-kind. USDA estimated that the number of unpaid farmworkers in 1987 was 3.6 million and that 65 percent of these worked fewer than 25 days during the year, with their labor concentrated during peak harvesting or planting seasons (105).

EPA estimated that 18 percent of all hired farmworkers applied RUPs in 1987 (61), but no other estimates are available for the number of farmworkers using other categories of agrichemicals. Farmworkers are probably involved more in agrichemical mixing, application, and equipment maintenance than in selecting the agrichemicals used. Training in proper handling procedures and supervision are key issues in the use of agrichemicals by farmworkers. Short terms of employment, lack of familiarity with equipment, and inadequate communication between the farmworker and farm operator are factors that can increase the chances of agrichemical mismanagement.

Commercial Applicator Groups

Many farmers hire outside contractors or custom applicators to apply agrichemicals to their fields and orchards. Farmers purchase custom application services because they may not own needed application equipment or they want to save time or labor. Approximately 30 percent of the farms having fertilizer expenditures and 22 percent of the farms having pesticide expenditures in 1986 paid for some custom application services (153). The percentage of farms using custom agrichemical application services has remained constant since 1980.

Farmers purchase agrichemicals and custom application services from a variety of outlets: 1) agrichemical dealerships owned by large, chain-type companies; 2) agrichemical dealerships that are individual, independent firms; 3) farmer cooperatives that sell agrichemicals and other farm supplies; 4) grain and feed manufacturing elevators; and 5) other agricultural service firms (e.g., cropdusting). Employees of these commercial firms play three distinct roles in agrichemical use and management.

Box S-B—Agricultural Sector Characteristics Influencing Decisionmaking

Constraints and opportunities in the agricultural sector will affect farmers' capacity to respond to concerns about agrichemical contamination of groundwater. Following are characteristics of the agricultural sector likely to influence agrichemical use and thus the potential for agrichemical contamination of groundwater:

Bimodal Structure of Agriculture—The **structure** of agriculture is represented by an uneven distribution of farms among small, moderate, large, and very large sizes based on annual farm product sales. The current agricultural sector can be described as "bimodal," with many small and part-time farms, increasing numbers of large farms, and declining numbers of moderate-size farms; the result of a long-term trend toward fewer and larger farms. If present trends continue, the total number of farms will decline at a rate of about 100,000 farms per year to 1.2 million in 2000. The number of large and very large farms is expected to increase substantially, although small and part-time farms are still expected to make up about 80 percent of total farms by 2000:

Sales class	Value of farm products sold[a]	Number of farms				Percent of farms			
		1969	1978	1982	2000 (Projected)	1969	1978	1982	2000 (Projected)
Small and part-time	<$99,999	2,588,031	2,191,361	1,936,920	1,000,000	94.9%	89.4%	86.5%	80.O%
Moderate	$100,000-199,999	85,589	160,289	180,689	75,000	3.1	6.5	8.1	6.0
Large and very large	>$200,000	54,491	97,391	121,691	175,000	2.0	4.0	5.4	14.0
All farms		2,728,111	2,449,041	2,239,300	1,250,200	100.0%	100.0%	100.0?(0	100.0%

[a]1982 dollars, **price indices** in *Agricultural Statistics,* 1988.

SOURCE: Office of Technology Assessment, *Technology, Public Policy, and the Changing Structure of American Agriculture.* **Compiled from data in** *Economic Indicators of the Farm Sector: Income and Balance Sheet Statistics,* **USDA Economic Research Service, 1988 and preceding years. Data adjustment for inflation based on redistribution of farm numbers in the** *Census of* **Agriculture, 1969, 1978, 1982, and 1987, Bureau of the Census, U.S. Department of Commerce,**

The trend toward increasing concentration in agriculture, however, may be significantly affected by environmental programs influencing agriculture in the 1990s. The 1985 Food Security Act signaled a period in which conservation and environmental groups began to participate to a greater extent in the drafting of farm legislation than ever before, and this trend is likely to continue given the public concern over food safety and groundwater contamination. It is not clear how increased legislative attention to agriculture's environmental impacts will influence the trend toward larger and fewer farms. Environmental regulations could accelerate the trend by increasing the cost of farming and requiring more recordkeeping and monitoring. On the other hand, environmental requirements could make it more difficult for large farms to achieve economies of scale (165).

Despite the uncertainty surrounding impacts of environmental policies on the structure of agriculture, concentration in agriculture is expected to continue. Economic policies, institutions, and economies of scale that have contributed to the trend toward concentration of agricultural resources are likely to continue unless strong public support for alternative policies is generated (144). The degree of concentration, however, will vary by region and commodity, and thus no predictions can be made about its effects on agrichemical contamination of groundwater.

Farm Income Trends—The agricultural sector's capacity to respond to voluntary programs for reducing groundwater contamination will be affected by financial constraints such as low commodity prices or increasing production costs. However, income for the smallest classes declined to a greater extent between 1969 and 1982 than did that of large and very large farms. Overall, half of all farm households depended primarily on off-farm income for family living expenses (14). The need for off-farm income imposes time and labor constraints on many farm households, with concomitant implications for the types of farming practices that farmers will be willing or able to adopt.

Farmland Ownership and Tenancy-Relative proportions and locations of rented and owned farmland in the United States have implications for groundwater protection programs. Nonfarmers owned about 36 percent of all farmland and 89 percent of rented farmland in 1982 (147). Farm operators may be less motivated to invest in groundwater protection activities on rented land than on their own land, especially when land is rented for short periods. Tenants also have less autonomy than landowners when making management decisions (143). Tenants and part-owners are operating an increasing proportion of the number of farms, managing increasing numbers of

Continued *on next page*

Box 5-B—Agricultural Sector Characteristics Influencing Decisionmaking-Continued

farmland acres, and accounting for increasing values of products sold (147). Landowners in hydrogeologically vulnerable areas will need to pay increased attention to agrichemical use decisions by their tenants. Tenants typically rent farmland under one of two main types of rental agreements-share leases and cash leases-which may impart different abilities or tendencies to adopt groundwater protection farming practices.

Contract Farming-Contract farming, including a range of contracting agreements through which farmers agree to produce and deliver farm commodities under conditions specified by a contractor, also is becoming more common (147). Types of production becoming increasingly associated with contract farming are poultry products, and fruits and vegetables Cattle feeding, hog production, and feed and forage production also have seen recent increases in contract farming. For example, commercial feedlots frequently contract with neighboring farmers to raise feed grains or forage. Contract farming has advantages for the contractor, who is able to secure a certain quantity of product of specified quality at an agreed-upon time. Producer advantages include financing, technical advice, and assurance of a market.

Contract farming has implications for agrichemical use, because contractors may require producers to use only specified types and amounts of inputs. Contract farming could result in greater agrichemical use, especially when producers are required to apply prophylactic pesticide treatments to meet contractor standards or to ensure a given yield at a certain time (10). On the other hand, contracting firms responding to public concern about agrichemical residues in foods may encourage producers to reduce agrichemical use when growing their products (e.g., Ocean Spray, Gerber Foods),

Vertical Integration-Vertical integration—securing two or more sequential production stages under the ownership of one corporate entity—increased in agriculture and food processing from about 5 to 7 percent between 1970 and 1980 (147). Vertical integration provides food processors a more stable and uniform supply of commodities, making it easier to meet consumer demand for high-quality and attractive produce. Some vegetable and fruit processing companies, for example, own land to produce some of their own crops. Little evidence is available on how increased vertical integration affects agrichemical use overall. Vertical integration in fruit and vegetable processing, for example, could intensify agrichemical use if prophylactic treatments were employed to protect capital investments and minimize production risks. Corporate responsibilities to stockholders can create cost-cutting pressures that would hamper adoption of practices requiring more time, management, or labor, thus requiring farm managers to seek support from stockholders to justify costs of changing farming practices to protect vulnerable groundwater resources. On the other hand, vertically integrated corporations tend to employ professionally trained managers who may be sensitive to public concerns about adverse environmental impacts from farming practices as well as food safety.

First, commercial firm employees advise farmers on the types and amounts of agrichemicals to be applied on farmers' fields. Employees who are: aware of potential environmental impacts and motivated to communicate environmental information are more likely to help farmers make better decisions, on which agrichemicals to use, when, where, and. how.

Second, commercial firm employees apply agrichemicals as custom services. Since roughly one-third to one-half of all agrichemicals in the agricultural sector are applied commercially (158,56), training and supervision of all commercial applicators are important considerations in strategies to reduce nonpoint agrichemical contamination of groundwater. Also, since EPA estimates that the average commercial certified RUP applicator supervises three to four noncertified applicators, as many as 80 percent of all commercial RUP applicators are potentially noncertified (121). Noncertified applicators have less forma! exposure to information on RUP application procedures, and some may not be well-trained on agrichemical application equipment. Training and supervision of part-time or seasonal applicators, particularly during peak planting periods, may pose special problems for permanent employees who are also pressed for time.

Third, commercial firm employees operate and maintain agrichemical storage, handling, and disposal sites, which represent significant potential sources of groundwater contamination, Adequate training and supervision of employees and their preparedness in handling accidental spills are critical factors in reducing point-source contamination of groundwater from agrichemical sales outlets.

The importance of commercial applicators in agrichemical application and management warrants attention to commercial firm numbers, locations, and methods of operation. Since certification requirements and work situations differ for commercial and individual agrichemical applicators, policy approaches to improve agrichemical management by these two groups are also likely to differ.

Agrichemical Dealerships

An agrichemical dealership is a retail outlet that purchases agrichemicals from a distributor and sells them to farmers. Dealerships may be independent firms with single outlets, franchises of large, chain-type companies (e.g., Terra, Inc.), or farm cooperative sales outlets. Roughly 80 percent of all dealerships sell both fertilizers and pesticides (129,27).

Distribution and size of dealerships reflect regional variation in the structure of agriculture: dealerships, like farms, are smaller and more numerous in the Midwestern and southern regions. Average annual pesticide sales per dealership, for example, are $300,000 to $400,000 in the Midwest and South, $500,000 to $600,000 in the Northwest, and almost $2 million in California (170). The Midwest and South have eight and five dealerships per thousand square miles, respectively, while one or two dealerships per thousand square miles are found in California and the Northwest region. The total number of dealerships is expected to decline by 20 to 25 percent by the year 2000, due to concentration in the industry from mergers and loss of small dealerships (170).

Fertilizer Dealerships—The National Fertilizer and Environmental Research Center of the Tennessee Valley Authority tracks the total number of registered or licensed fertilizer dealers for all States. Fertilizer dealerships in 1987-88 totaled 13,044, including fertilizer manufacturers and bulk blending and fluid fertilizer plants having fertilizer sales outlets (56). Fertilizer manufacturers and blenders generally sell directly to dealers, rather than through distributors, because fertilizers are high-bulk commodities. Fertilizer is typically shipped by rail or barge to a central point (often owned by the manufacturer), where dealers come to pick up the product.

Pesticide Dealerships—Neither EPA, USDA, nor the Department of Commerce collects data on the number of pesticide dealerships nationwide. Some States require licensing of pesticide dealers, but these States do not report numbers of licensed pesticide dealers to any Federal office. National estimates for pesticide dealers vary widely, from an industry estimate of 5,600 (129) to an EPA estimate of 32,400 (61). Other estimates typically used in the pesticide industry range between 12,000 and 16,000 (27).

Thus, no national data exist on the numbers, locations, and facilities of pesticide dealerships, making it difficult to monitor industry trends or to estimate aggregate costs of proposed regulations or facility improvements. State and Federal records on dealerships would make it possible to evaluate the progress of industry and government initiatives to improve handling, storage, and disposal at these sites. Also, if large numbers of small dealerships go out of business in the next decade as predicted, records on their numbers and locations would make it possible to monitor abandonment of facilities to ensure environmental compliance.

Farmer Cooperatives-A farmer cooperative is a membership organization in which farmers have controlling interest. Farmer cooperatives are incorporated under State laws and classified as marketing, farm supply, or service cooperatives, depending on their primary business. The USDA's Agricultural Cooperative Service (ACS) provides annual statistics on farmer cooperatives. In 1987 an estimated 3,000 of the 5,100 farmer cooperatives in the United States sold agrichemicals (150). Many farmer cooperatives are members of regional or interregional cooperative organizations, with the 16 largest regional cooperatives handling about 40 percent of all fertilizer products sold in the United States. CF Industries, for example, is an interregional fertilizer manufacturer owned by 13 regional cooperatives supplying fertilizers to 1.2 million farmer-members in 46 States (171).

Farmer cooperatives that supply agrichemicals help their members obtain secure, competitively priced supplies of fertilizers and pesticides. Employees of farm-supply cooperatives perform agrichemical management roles similar to those of employees of agrichemical dealerships. In theory, a farm-supply cooperative differs from other types of agrichemical dealerships in that it is owned by members who join the cooperative to enhance their own farming operations rather than to earn income from the cooperative business. Thus, farmer cooper-

atives would appear to have stronger incentives to employ well-trained custom applicators and to help their members reduce excess agrichemical inputs. However, cooperatives are run by hired managers, whose salaries and job stability depend on demonstrating good business performance through strong product sales. As a result, cooperative managers, like dealership employees, face the possible disincentive of reduced sales if they advise farmers to reduce agrichemical use.

Some farmer cooperatives, on the other hand, exist solely to provide advisory and field scouting services to their members and do not sell agrichemical products. One example is Centrol, Inc., a subsidiary of Cenex-Land O'Lakes headquartered in Minnesota. Such cooperatives presumably would not have an interest in providing recommendations that increase volumes of products sold.

Agricultural Service Firms

Commercial applicators may be employed by agricultural service firms other than agrichemical dealerships and farmer cooperatives. These include agricultural contractors, crop protection firms, agricultural aviation or cropdusting firms, and agricultural management companies. Information on trends, numbers, and types of services available from agricultural service firms is helpful in assessing these fins' roles and significance in agrichemical management.

Many agricultural service firms are classified under the Standard Industrial Classification (SIC) code ''07' as establishments that obtain at least half of their sales income by providing the following agricultural services:[3] soil preparation, crop, veterinary and animal, farm labor and management, and landscape and horticultural services. Employees of many such service firms are likely to handle agrichemicals. The most current estimates of these fins' numbers are available in County Business Patterns (CBP) data from the U.S. Department of Commerce. CBP estimates, however, are probably low, because they represent counts only of larger firms with payrolls reportable to the Internal Revenue Service (163). CBP estimates do not include many self-employed agricultural contractors or small service firms having mostly part-time workers.

Photo credit: U.S. Department of Agriculture, Agricultural Research Service

Wire-mesh cones baited with pheromones contain sensors that count insects flying into the trap. Field scouts may routinely use similar technologies in the future to advise farmers on the need for agrichemical applications.

More accurate estimates of the numbers of these firms had been obtained every 5 yearn through the Agricultural Services Survey of the Census of Agriculture, but this survey was discontinued for lack of funding in 1979. The Agricultural Services survey attempted to reach as many small firms as possible and required a mandatory survey response (178). As a result, its national estimates of the numbers of firms classified under ''07' SIC codes were roughly twice as high as CBP estimates (e.g., 93,100 compared to CBP's 40,900 in 1978) (163).

CBP data can be used to assess trends among larger agricultural service fins, recognizing that these data tend to underestimate total numbers of

[3]This definition does not include wholesale farm supply firms or farmer cooperatives.

Figure 5-1—Increase in U.S. Establishments Primarily Engaged in Selling Landscape and Horticultural Services,[a] Estimated Numbers of Establishments and Employment, 1974-86

[a]Estimates for establishments classified under SIC Code 078, which includes lawn and garden services, ornamental shrub and tree services, and tree services, and landscape counseling and planning.

SOURCE: U.S. Department of Commerce, Bureau of the Census, County Business Patterns, table 1 b. Washington, DC, 1986 and previous years.

Figure 5-2-increase in U.S. Establishments Primarily Engaged in Selling Farm Management Services,[a] Estimated Numbers of Establishments and Employment, 1974-86

[a]Estimates for establishments classified under SIC Code 0762, primarily engaged in providing farm management services, including management or complete maintenance of citrus groves, orchards, and vineyards. Such activities may include cultivating, harvesting, *or* other specialized activities.

SOURCE: U.S. Department of Commerce, Bureau of the Census. *County Business Pa tterns*, table 1 b. Washington, DC, 1986 and previous years.

Figure 5-3-Changes in U.S. Establishments Primarily Engaged in Wholesale Distribution of Farm Supplies,[a] Estimated Numbers of Establishments and Employment, 1974-86

[a]Estimates for establishment classified under SIC Code 5191, which includes those primarily engaged in the wholesale distribution of farm supplies includes selling of merchandise to farm users.

SOURCE: U.S. Department of Commerce, Bureau of the Census. *County Business Patterns,* table lb. Washington, DC, 1986 and previous years.

fins. During the 1970s, all types of agricultural service firms increased in number. From 1974 to 1984, for example, the number of landscape (including lawn care) and horticulture service firms doubled (figure 5-l), which implies that concomitant increases in agrichemical applications occurred during this time in residential and commercial areas. The rapid growth of landscape and horticulture service firms thus has implications for urban contributions to groundwater contamination by agrichemicals and for the need to adequately train and supervise service firm employees to reduce contamination.

An increase in service firms was also seen in the agricultural industry during the 1970s, due to record growth in both domestic and export agricultural markets. The number of farm management fins, which operate farms for absentee owners or investors, more than doubled during this decade (figure 5-2). Expansion of agricultural services paralleled increases in planted acreage, crop production, land values, price supports, available cash to producers, and input prices in the 1970s (31). In the 1980s, however, reductions in planted acreage and farm financial stress led to loss or merging of some agricultural service firms, indicated by lower CBP estimates (figure 5-3). Despite lower input prices, farmers were using fewer inputs and demanding fewer services in the 1980s. The fertilizer industry also reported a decline in the sale of in-house advisory services by dealers and blending plants during this period (174). Agricultural service firms thus were affected by the economic contraction in agriculture in the 1980s, although agriculture is likely to recover some financial strength in the 1990s.

Agricultural service industry trends will influence the responsiveness of these firms to environmental concerns by affecting their ability to invest in new company start-ups, additional employee training,

and service innovations. Better Federal data on the numbers and types of agricultural service firms would facilitate tracking and assessment of the roles of service firms in improving agrichemical management and providing agrichemical alternatives. Environmental services development and employee training programs for agricultural service firms would enhance the technical support farmers receive from the private sector. Lack of comprehensive data. however, makes it difficult to assess the progress. needs, and opportunities of service firms[4] (165).

Applicator Certification and Training: Needs and Opportunities

Applicator certification requirements, as noted earlier, pertain to restricted-use pesticides (RUPs) in all cases, general-use pesticides in some cases, and fertilizers in no cases. Thus, mandatory programs for applicator certification and training primarily address regulatory needs of RUP applicators, but RUPs constitute only a small proportion of the total volume of agricultural pesticides used (less than 20 percent in 1987, box 5-A). Even though pesticide applicator training and educational materials are available, persons who are not required to be certified or trained (e.g., private agrichemical users in urban areas and farmers who use only fertilizers and general-use pesticides) may never take advantage of these opportunities. Thus, the main means of encouraging proper use of most agrichemicals is through provision of product labeling information and applicators' voluntary compliance with label directions.

States have primary responsibility for pesticide applicator programs but they must follow EPA competency standards (see box 5-C) and planning guidelines in implementing applicator certification programs (38). Each State has a designated pesticide "lead agency" responsible for certifying RUP applicators as competent to handle pesticides in several technical categories, including agricultural use (154). EPA requires States to give commercial applicators a written test for initial certification, but States are not required to test private applicators or to train commercial or private applicators. Although States are required to recertify applicators, the recertification interval is not specified.[5] Some States have implemented certification and training procedures that are more stringent than EPA requirements, and as a result, applicator certification and training procedures and opportunities vary from State to State.

Box 5-C-Competency Standards for Pesticide Applicator Certification

Standards for certification of commercial applicators require that competence be determined by written examinations and, where appropriate, by performance testing (38). Commercial applicators must meet general standards as well as standards specific for each category. General standards for commercial applicators are: 1) comprehension of labeling information, 2) knowledge of safety factors, 3) environmental consequences, 4) pests, 5) pesticides, 6) equipment, 7) application techniques, and 8) relevant laws and regulations.

Category-specific standards for agricultural plant pest control applicators include practical knowledge of: 1) crops, **2)** pest targets, 3) soil and water problems, 4) time intervals needed between pesticide application and crop harvest, 5) time intervals needed between pesticide application and worker entry into treated fields, 6) plant toxicity problems, and **7)** potential for environmental contamination, nontarget injury, and community problems resulting from pesticide use (169). Category-specific standards for ornamental and turf pest control applicators include knowledge of: 1) pesticide problems in production and maintenance of trees, shrubs, plantings, and turf; 2) potential plant toxicity; 3) problems of drift and persistence; and 4) application methods which minimize or prevent hazards to humans and domestic animals.

EPA has no other requirements for written examinations for commercial applicators. Thus, the examinations may be either open-or closed-book or take-home. Neither does EPA specify a passing grade for the examination. In practice, however, most States require a passing grade of 70 percent correct answers and require commercial applicators to go through performance tests with application equipment. EPA requires States to renew all applicator certifications, but the time internal for recertification is not specified.

[4]Lack of Federal data has also been noted for environmental service firms (165).

[5]EPA is proposing a revision to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulations that would require States to establish a minimum recertification interval of 5 years.

Although it is not known whether groundwater contamination has resulted more from agrichemical mismanagement than from ‘‘proper’ application of leachable chemicals, it is clear that programs to reduce potential contamination must include training and education to improve agrichemical management. The Federal Government provides only a minor share (20 percent) of funding spent on RUP applicator training and States provide the remainder (156). In the absence of additional funding from State sources, the Federal Government will likely need to increase financial support so that applicator education programs can: 1) implement new regulatory requirements for current applicators, expand topics covered in current programs, and extend the length and frequency of training; and 2) train audiences not currently covered by Federal or State regulations. Federal leadership and support for training and education in agrichemical management would expedite programs that reduce mismanagement overall, as well as address the needs of people currently using agrichemicals in hydrogeologically sensitive areas.

Applicator Testing for Certification

States must administer an EPA-approved written test to commercial agricultural applicators prior to certification, but States can employ a variety of methods in certifying private applicators as ‘ ‘competent, ’ as long as the method is approved by EPA. At a minimum, private applicators must demonstrate practical knowledge of pest problems; pest control practices; proper pesticide storage, handling, application, and disposal procedures; and related legal responsibilities. Private applicators must show that they are able to apply pesticides in accordance with label instructions and warnings and recognize local environmental situations that should be considered during application. Private applicator certifications may be granted through examinations (e.g., oral, written, closed-book, open-book, take-home, graded, pass/fail, or ungraded) or other “equivalent” systems, such as training, self-study, and self-evaluation. Private applicator testing procedures thus vary widely and may be less rigorous than those for commercial applicators (166).

Since both private and commercial applicators are responsible for controlling point-source and nonpoint-source contamination of groundwater by pesticides, ideally all applicators should be able to demonstrate equivalent levels of knowledge about contamination risks and proper control methods, particularly if they are certified to apply pesticides in hydrogeologically vulnerable areas. However, EPA’s most recent national survey of State applicator certification and training programs, conducted in 1986, indicated that commercial applicators’ exams have been more extensive than private applicator exams (166). For example, fewer private applicator exams contained questions on groundwater vulnerability and pesticide leaching, and only one commercial applicator exam (and no private applicator exams) covered local groundwater conditions (table 5-7). Since the year in which EPA conducted the survey, however, some progress has been made in updating certification and training programs to address groundwater quality concerns. In 1988, for example, USDA disseminated to all State Cooperative Extension Services (CESs) a slide-tape program on groundwater protection for pesticide users (117). Closer coordination between State CESs and pesticide lead agencies in developing applicator examinations and training would improve applicators’ ability to address emerging environmental concerns.

Table 5-7—Number of States in 1986 Specifically Addressing Groundwater Concerns in Pesticide Applicator Certification Training and Testing Programs

Applicator program for certification	Initial certification		Recertification	
	Private	Commercial	Private	Commercial
Training:				
General groundwater vulnerability	29	28	24	29
Pesticide movement through soils	32	36	28	34
Local groundwater conditions	7	8	13	14
Testing:				
General groundwater vulnerability	10	15	7	6
Pesticide movement through soils	18	26	12	19
Local groundwater conditions	0	0	0	1

SOURCE: U.S. Environmental Protection Agency, Office of Pesticide Programs, Certification and Training Branch, draft report, “Review of State Plan Questionnaires on Certification and Training, Preliminary Summary of Results,” Apr. 8, 1987, pp. 38-43.

Applicator Training and Education

EPA does not require States to train private or commercial applicators, but it does fired development of pesticide education and applicator training materials (see box 5-D). Each State develops its own pesticide applicator training (PAT) materials, typically through the CES PAT coordinators in conjunction with the State's pesticide lead agency (155). The CES is responsible in most States for applicator training, but the State's pesticide lead agency can also approve other applicator training programs (e.g., by private industry). In 1989, State CESs trained about 500,000 people nationwide, although the number of people trained each year varies, due to changes in State laws and fluctuations in applicator recertification cycles. State CESs have given applicator training to as many as 1 million people in 1 year (1 16).

At the Federal level, EPA's Certification and Training Branch in the Office of Pesticide Programs and the USDA Extension Service (ES) share responsibilities for pesticide applicator training. USDA provides the salary for a National Program Leader for Pesticide Education to help guide and coordinate State CES activities, while EPA provides pesticide training funds that are allocated by formula to State CESs through USDA. From 1982 to 1990, EPA gave USDA about $1.6 million annually for pesticide training. Thus, the Federal Government spends less than $1 for pesticide training per agricultural applicator per year.[6]

Each State CES annually receives at least $15,000 in Federal base funding for pesticide certification training. Some of the larger agricultural States receive the highest amounts of EPA funding at about $60,000 per year (116). Applicator certification training funds are in addition to other EPA funds given to State pesticide lead agencies for pesticide regulation and enforcement. EPA has also provided some discretionary funding for special projects to support development of pesticide education bibliographies and computer software (44) by USDA's National Agricultural Library (157).

The amount of State funding for pesticide training varies from State to State, which results in varied staffing levels for PAT programs. In many States, one PAT coordinator is responsible for all pesticide training and education programs. Many PAT coordinators have additional job responsibilities and may only be appointed to work one-quarter or one-half time on pesticide training. States also vary in the lengths of their applicator training programs, which range from 2 to 6 hours (166), and in the methods used to verify that trainees understand the information presented during training. In some States, for example, applicators must fill out a worksheet when training has been completed, while in other States mere attendance at a training session is sufficient to receive a training certificate. Thus, applicator training methods and requirements, like testing procedures, vary widely from State to State.

Currently, CES pesticide education programs are facing extensive additional program demands as a result of new or proposed EPA regulatory provisions on farmworker safety, endangered species protection, groundwater protection, and applicator supervision requirements (156). Furthermore, inadequate resources for PAT programs has made it difficult for States to hire staff, regularly update PAT materials, and incorporate new information in training programs. Many PAT programs are using outdated educational materials that may not reflect the most recent techniques for controlling pests, or address environmental concerns that have recently emerged. Inadequate staffing and outdated educational materials in pesticide training programs will hamper State responsiveness to public concerns about agrichemical contamination of groundwater.

Supervision of Noncertified Applicators

All noncertified RUP applicators must be under the direct supervision of a certified applicator. ''Direct' supervision is defined as "the act or process whereby application of a pesticide is made by a competent person acting under the instructions and control of a certified applicator who is responsible for the actions of that person and who is available if and when needed, even though such certified applicator is not physically present at the time and place the pesticide is applied" (38,169). This definition is open to interpretation. FIFRA regulations specify only that the certified applicators' availability to the noncertified person be directly related to the hazard of the situation, but ''hazard' is not clearly defined. Thus, it is difficult to monitor and enforce application procedures by noncertified applicators.

[6]In 1989, EPA estimated there were 2.3 million agricultural RUP applicators, including certified and noncertified applicators (refer to table 5-4).

Box 5-D—EPA's Pesticide Applicator Certification and Training Program

The goal of the EPA Office of Pesticide Program's Certification and Training (C&T) program is to prevent potential pesticide problems by providing funding, guidance, and coordination for pesticide applicator certification and training. The C&T program is located in OPP's Field Operations Division to create and maintain cooperative relationships and communications among EPA regional offices, other Federal agencies, and the States (167). The C&T program performs the following roles:

- **Provides funds to** USDA to support materials **development and CES training of pesticide applicators:**
  - **-Gives training** funds to USDA through a USDA/EPA interagency agreement, authorized by Section 23(c) of FIFRA. USDA then allocates funds to State CES pesticide applicator training programs.
  - --Gives discretionary funds to USDA for special initiatives, such as the National Agricultural Library clearinghouse for applicator training materials.
- Guides and funds State certification programs:
  - —Reviews State certification program plans, mainly to ensure that Part 17140 CFR requirements are met. Once a State program is approved, EPA has little influence on State programs, outside of informal discussions.
  - -Oversees cooperative agreements on certification programs, which are negotiated between EPA regional offices and State lead agencies.
  - —Provides formula funding to States for their certification programs through EPA regional offices. EPA funds are matched by the States and are based on numbers of applicators certified, numbers of farms, and whether or not the States have recertification provisions.
- **Develops, funds, and evaluates pesticide training materials:**
  - —Identifies areas in need of training materials (e.g., farmworker safety, chronic health effects, endangered species).
  - —Solicits proposals for developing training materials from USDA, the States, private-sector contractors, universities, and the private sector.
  - -Grants discretionary funds for development of training modules and training initiatives, such as State special projects.
  - —Funds the Public/Private Pesticide Initiative for Pesticide Training and Education (P/PSI), a cooperative effort between EPA, the National Association of State Universities and Land Grant Colleges, and industry to support development and dissemination of training materials by the private sector,
  - —Helps coordinate private organizations' efforts in applicator training through the P/PSI Commission, which consists of industry, environmental, user, and farmworker group representatives.
  - —Supports seminars and workshops (e.g., to train Native American tribal officials on certification program administration).
  - —Reports periodically on certification and training materials in "The Certification and Training Update. "
  - —Conducts joint reviews with USDA of the State's private applicator training programs. Data from these reviews are used to identify weaknesses and strengths and to improve training programs. Half of the 27 State programs reviewed in FY 1988 had not yet included groundwater quality concerns in their programs.
- . Develops State grant guidance to coordinate pesticide-related activities:
  - —Works with other EPA offices to establish guidelines for States to develop consolidated cooperative agreements with EPA. Such an agreement allows a State to obtain funding from EPA on all pesticide activities for which financial aid is available.
- . Develops regulations for pesticide applicator training:
  - —Proposes revisions to Part 171 CFR 40 regulations pertaining to pesticide applicator training.

EPA is proposing regulations and labeling changes that classify RUPs into three hazard categories with different supervisory requirements: 1) "Hazard Level One" pesticides may be applied only by certified applicators; 2) ''Hazard Level Two' pesticides may be applied by a noncertified applicator if a certified applicator is on-site and available within 5 minutes; and 3) ''Hazard Level Three" pesticides may be applied by a noncertified applicator when a certified applicator is not on-site but is available within a''reasonable' amount of time (167). If these proposed changes are implemented, supervisory requirements will be defined more narrowly, although the word "reasonable" for Hazard Level Three pesticides is still ambiguous. Unclear supervisory requirements may cause more people to become

certified for fear that they might misinterpret or fail to comply with new regulations. Increased demand for applicator certifications would increase PAT program participation and CES training workloads.

States are not required to report names or numbers of noncertified RUP applicators to EPA. Since EPA can only estimate the numbers of noncertified RUP applicators in the field, it is difficult to assess costs of regulatory changes affecting noncertified applicators. Furthermore, information is unavailable on how States verify and monitor supervisory competence of certified applicators, even though FIFRA regulations state that certified applicators ''whose activities indicate a supervisory role' must demonstrate their knowledge of any supervisory requirements for RUP use (38). Thus, the quality of training and supervision received by noncertified applicators may also be highly variable from State to State.

Obtaining an Overview

EPA does not maintain an annually updated national overview of State pesticide applicator certification and training programs (12 1). Each State lead agency for pesticide programs must be contacted for current information in order to track applicator certification and training activities within the State (123). The lack of comprehensive national information makes it difficult to obtain an overall picture of applicator certification and training programs. EPA apparently does not maintain a high level of activity in monitoring applicator programs because States have primacy in this area, and because EPA's mandate is primarily regulatory rather than educational. However, the lack of regular Federal oversight on State applicator programs nationwide could hamper national responsiveness to environmental concerns related to pesticide use.

The 1986 EPA survey of State pesticide applicator certification and training programs indicated which States exceeded FIFRA requirements for applicator certification (e.g., written exams required for private applicators; training required for private and commercial RUP applicators) (166). Of the 53 States and Territories surveyed, only 16 required training for initial private applicator certification and only 9 required training for commercial applicators (table 5-8). Survey data for 10 States ranked as the highest-volume users of agricultural pesticides are given in table 5-9 (45). Of these States, only seven required either testing (Illinois, Minnesota, Indiana, and Ohio) or training (Nebraska, Texas, and Arkansas) for private applicators. Only Texas required training for commercial applicators. It should be emphasized that some of these States (e.g., Iowa)

Table 5-8—Number of States and Territories[a] That Required Training for Restricted-use Pesticide Applicators in 1986[b]

Requirement	Number of States	States or Territories
Private applicators-initial certification:		
Training required	16	AL. AR, HI, KY, LA, MO, ND, NE, OK, PR, SC, SD, TN, TX, VI, WI
Training not required	36	AR, AZ, CA, CO, CT DC, DE, FL, GA, 1A, ID, IL, IN, KS, MA, MD, ME, MI, MN, MS, MT NC, NM, NH, NJ, NV, NY OH, OR, PA, RI, UT, VA, VT, WA, WY
No response	1	WV
Private applicators-certification renewal:		
Training required	13	AL, ID, KY MD, ND, OK, PA, PR, RI, SD, TN, Vi, WI
Training not required	38	AK, CA, CO, CT, DC, DE, FL, GA, HI, 1A, IL, IN, KS, IA, MA, ME, MI, MN, MO, MS, MT, NC, NE, NH, NJ, NM, NV, NY, OH, OR, SC, TX, UT, VA, VT, WA, WV, WY
No response	2	AR, AZ
Commercial applicators-initial certification:[c]		
Training required	9	MD, ND, NJ, NM, NY, PR, TX, WA, WI
Training not required	44	AK, AL, AR, AZ, CA, CO, CT DC, DE, FL, GA, Hi, 1A, ID, IL, IN, KS, KY, LA, MA, ME, MI, MN, MO, MT, MS, NE, NC, NH, NV, OH, OR, OK, PA, RI, SC, SD, TN, UT, VA, VI, VT WV, WY
Commercial applicators-certification renewal		State information not available.

[a]Territories included Puerto Rico and the Virgin Islands.
[b]This table presents States' certification and training status in 1988 and does not indicate changes which may have occurred since that year.
[c]All commercial applicators are required to take a Written exam to be certified.

SOURCE: U.S. Environmental Protection Agency, Office of Pesticide Programs, Certification and Training Branch, draft report, "Review of State Plan Questionnaires on Certification and Training, Preliminary Summary of Results," Apr. 8, 1987.

Table 5-9-Applicator Certification and Training Provisions in Ten States[a] With Highest-Volume Agrichemical Use, 1986 Status[b]

Provision	States in descending order of pesticide volume used 1A	IL	MN	IN	OH	CA	NE	TX	AR	MS
Private applicators:										
Initial certification:										
Mandatory testing	-	+	+	+	+	+	-	-	-	-
Voluntary testing				+	-	-	+	-		+
Mandatory training				-	-		+	+	+	-
Voluntary training							+	+	+	+
Certification renewal:										
Mandatory testing	-	+	+	+						
Voluntary testing	+				+		+	-		+
Mandatory training							-	-	-	-
Voluntary training							+	+	+	+
Commercial applicators:										
Initial certification:[c]										
Mandatory training							-	-	-	-
Voluntary training[d]							-	+	+	+
All applicators:										
1PM materials available	+			+	-	+	+	+	+	+
Training offered for noncertified applicators						-	+	-	+	-[e]

[a]Ten States ranked as highest volume users of agricultural pesticides in Resources for the Future national pesticide usage database (45).
[b]Blank spaces indicate "no response reported."
[c]Written examinations for certification of commercial applicators is required by law.
[d]Voluntary training provided through State cooperation with industry.
[e]Training materials available to noncertified applicators on request.

SOURCE: U.S. Environmental Protection Agency, Office of Pesticide Programs, Certification and Training Branch, draft report, "'Review of State Plan Questionnaires on Certification and Training, Preliminary Summary of Results," Apr. 8, 1987.

have implemented new pesticide laws or regulations that are not reflected in the 1986 survey data.[7]

Opportunities for Applicator Certification and Training

Applicator certification and training programs are important intervention points in State pesticide programs, because they can help Federal and State governments ensure a certain level of competence among pesticide applicators. One way for States to respond to groundwater contamination problems would be to evaluate how applicator certification and training programs could be expanded or enhanced to improve agrichemical selection based on soil and hydrogeologic conditions, reduce mismanagement, or incorporate information on alternatives to pesticide use.

States can evaluate possible program changes by assessing information shared among pesticide lead agencies (e.g., through the American Association of Pest Control Officials) and CES pesticide education coordinators (e.g., through regional and national PAT workshops). Another vehicle for program assessment is the State-Federal Issues Research and Evaluation Group (SFIREG), composed of representatives from State agencies responsible for pesticide enforcement, certification, and training. SFIREG Working Committees (e.g., Enforcement and Certification, Groundwater Protection, and Pesticide Waste Disposal) review, evaluate, and make recommendations on regulatory changes proposed by EPA. Recommendations for certification and training activities that go beyond EPA requirements have been presented by EPA/SFIREG Certification and Training Task Force (167).

Although some States have responded to groundwater contamination concerns by requiring training for all RUP applicators or by incorporating groundwater information in training programs, States' use of certification and training programs as a strategy to reduce agrichemical contamination of groundwater has three serious limitations. First, certification programs are limited to RUP applicators unless States enact legislation authorizing broader coverage. The lack of applicator certification requirements for fertilizers and general-use pesticides has

[7]In Iowa, applicator training remains optional for initial certification of private and commercial applicators, but continuing education is required for recertification. Also, Iowa now requires certification for 'pesticide handlers, ' who do not apply pesticides but who mix, handle, and dispose of pesticides at commercial sites. FIFRA only requires certification for RUP applicators.

groundwater quality implications, because the two most prevalent groundwater contaminants are nitrate and atrazine, an herbicide which had been registered as a general-use pesticide until February 1990 (29,5 1). The high frequency of groundwater contamination by these two categories of agrichemicals reflects their greater capacity to leach through soils but may also reflect overuse or mismanagement that could be addressed through expanded certification and training requirements. Thus, one way for States to help reduce nitrate and herbicide contamination of groundwater would be to require certification and training for applicators of fertilizers and general-use pesticides.[8] Increased certification and training requirements could be implemented either statewide or only in hydrogeologically vulnerable areas with documented groundwater contamination.

A second drawback to using applicator certification and training programs as a way of addressing groundwater concerns is these programs' history of being inadequately funded. Although FIFRA authorizes EPA to provide up to 50 percent of the funding for States to implement pesticide programs, EPA's share of total pesticide program funding is currently much lower. A funding survey of the 50 State pesticide lead agencies, State CESs, and four Territories in 1989 indicated that States provide about 70 percent of all pesticide program funding while EPA provides only 30 percent (2). The Federal share is even lower for applicator certification and training programs (156). Furthermore, States are being required by EPA to implement new pesticide initiatives starting in 1990 without receiving concomitant increases in EPA funding for these efforts. Lack of funding will hinder efforts to enhance or expand applicator education programs.

The third drawback is that applicator certification and training programs have been established to support agrichemical use, but not reduced-input or nonchemical farming practices. The latter may be the only techniques that will significantly reduce groundwater contamination in some hydrogeologically vulnerable areas. Expansion of training programs to include greater emphasis on integrated pest management or alternative farming practices, however, would require significant funding and involve a risk of spreading training resources too thinly. One alternative would be to create additional basic training or continuing education programs with earmarked funding, although such programs are unlikely to have strong impacts on target audiences unless all applicators are given incentives or required to undergo additional training.

As currently implemented, FIFRA requirements for RUP applicators are weak. Moreover, strengthening RUP applicator requirements could improve pesticide management by certified applicators, but these changes would not affect most users of general-use pesticides or fertilizers under current statutes. Agrichemical applicators thus have inconsistent and unequal access to preparatory and in-service training, certification and recertification procedures, supervision, and performance evaluation. This inconsistency is at least partly due to the Federal policy of granting States primacy and flexibility in their pesticide programs, but it also stems from a lack of clear congressional directives on applicator requirements and low levels of Federal funding for applicator training.

Inconsistency and lack of training in applicator programs thus leads to highly variable levels of management skills among agrichemical applicators and appears to represent a high potential for agrichemical mismanagement. Clearly defined and expanded Federal directives for applicator preparation and training may be needed to improve agrichemical management, because large numbers of individuals use agrichemicals under widely varying situations; monitoring and enforcement of agrichemical management are extremely difficult; and penalties for mismanagement may not serve as effective deterrents (proving mismanagement after the fact is also difficult). Wide discrepancies in certification, training, and supervision opportunities for agrichemical applicators represents a serious deficiency in the Federal effort to assure that agrichemicals are applied properly across the Nation. Clear Federal directives for applicator certification and training could reduce the incidence of agrichemical mismanagement and waste.

[8]EPA's Special Review and Registration Division is developing a proposed "ground water restricted-use' rule currently under review by OMB and USDA. Under the proposed rule as initially drawn up, as many as 25 chemicals could become classified as restricted-use pesticides if they are: 1) detected in three separate geographical regions; and 2) meet one of several technical criteria on chemical persistence and mobility (51).

FACTORS INFLUENCING AGRICULTURAL DECISIONMAKING

Factors influencing farmer decisionmaking, in general, and input choice and agrichemical use, in particular, will affect farmer decisionmaking related to groundwater protection. Technical assistance strategies, tools, and programs will be more effective in facilitating farmer decisions to reduce groundwater contamination if they take these factors into account.

Social science researchers have studied farmer decisionmaking over the past 50 years, at first examining decisionmaking involved in the "diffusion," or spread of agricultural innovations among farmers. More recently, researchers have studied farmers' adoption of conservation practices as well as decisions made within the context of "farming systems. Although little research has been conducted specifically on adoption of technologies to reduce groundwater contamination, decisionmaking research in general provides some relevant insights. For brevity, this discussion on decisionmaking refers to all private applicators as ''farmers, although some applicators will probably have more latitude than others in deciding which agrichemicals to apply, when, and how (e.g., Ml-time farm owner-operators v. hired employees).

Research on diffusion of innovations provides a basic understanding of the decisionmaking process and identifies the characteristics of innovations that are most likely to be adopted. Diffusion research, however, has limited applicability because it has focused largely on adoption of productivity-increasing technologies (1 13,127). Research on farmer adoption of soil conservation practices is more relevant to decisionmaking to reduce groundwater contamination because it identifies obstacles to adopting resource-protecting practices (98). However, institutional obstacles (e.g., farm programs, tax and credit policy), which many researchers consider more influential than the characteristics of individual farmers or technologies, have only begun to be investigated (90). Although farming systems research considers institutional influences on decisionmaking, much of this research has been conducted in other countries and is not immediately applicable to decisions made within the U.S. policy framework (cf: 77,12,9). Thus, each type of research has shortcomings, but lessons from research findings can be synthesized to help identify possible implementation problems in groundwater protection programs. Relevant findings are highlighted below.

Farmers are a heterogeneous group with unequal abilities and unequal access to information and resources for decisionmaking. Farmers vary in their objectives, level of awareness, use of information, and willingness to take risks; factors strongly influencing some farmers may have very little effect on others. Flexible groundwater protection programs and policies could be designed to accommodate this variation (13,100).

Farmers' decisions are based on their fundamental reasons for farming; their objectives may not be clearly defined or articulated. Farmers' objectives include: making a satisfactory living (either as an owner-operator, tenant, or employee); keeping a farm in operation for family inheritance or other personal reasons, perhaps while working at an off-farm job; obtaining a satisfactory return on investments in land, labor, and equipment; obtaining tax benefits from the farm; obtaining recreation or esthetic enjoyment from the farm; or a combination of these. Farmers' decisions to reduce agrichemical contamination will be made within the context of these basic objectives. Farmers are more likely to view favorably, and use, those technologies that allow them to meet their objectives (128).

Economic factors exert important, but not sole, influences on farmer decisionmaking. Fixed-cost expenditures and the farm family's total budget (on-farm and off-farm) place limits on actions farmers can take. Economic factors are key in defining what is financially possible for farmers, but a variety of personal, cultural, and environmental factors also shape farmers' decisionmaking. These include time and information availability, parental and sibling partnership arrangements, and influence of informal social networks (104,15,136,103). Economics will not be the only factor dictating adoption of groundwater-protecting farm practices.

Farmers typically make production decisions within short timeframes, which discourages investments in resource protection measures. Farmers currently operate in an economy that places higher priority on short-term returns and income guarantees than on longer-term resource conservation (135). Economic factors are typically the most pressing in farmer decisionmaking; market prices,

support levels, credit availability, and debt load are critical considerations at the individual farm level. Farmers often are forced to make decisions within a short-term, year-to-year planning horizon that can prevent them from taking risks or making the most economically efficient decisions over a longer term (13). Farmers asked to respond voluntarily to public concerns about groundwater contamination tend to evaluate proposed technologies for their relative advantage within the existing set of economic conditions (128,41).

Farmers make changes slowly. Farm management changes, even relatively minor ones, are not decisions made overnight. Farmer adoption of relatively simple, highly profitable technologies such as hybrid corn has taken as long as 9 years on average (128). The decision to change farming practices requires a considerable degree of deliberation, and maintaining new changes frequently necessitates on-farm experimentation and adaptation beyond that conducted during initial technology development.

A farmer's innovation decision process consists of several sequential stages. These proceed through: 1) knowledge, when the farmer learns about an innovation; 2) persuasion, when the farmer forms a favorable or unfavorable attitude toward the innovation; 3) decision, when the farmer chooses to adopt or reject the innovation; 4) implementation, when the innovation is put to use and possibly modified; and 5) confirmation, when the farmer seeks reinforcement of the decision already made, possibly reversing it if confronted with conflicting messages (128). Farmers need different kinds of information and use different communication channels at each stage (103).

Farmers adopt "preventive innovations'" more slowly than "incremental innovations.'? Agricultural innovations studied in most diffusion research have been ''incremental innovations, ' or ideas adopted in the present (e.g., hybrid corn, commercial fertilizers) to gain possible increases in value in the future. Many agricultural innovations to reduce agrichemical contamination of groundwater, however, will be ''preventive innovations. ' These are new ideas adopted in the present to avoid possible loss in the future (127). Adoption rates of preventive innovations usually are slower than those for incremental innovations. Also, the motivation to adopt a preventive innovation is often a cue-to-action, or an event that prompts translation of an attitude into overt behavior (128). Personal and family health concerns about drinking water impacts are potential cues for farmers to adopt practices to protect groundwater.

Individual and farm characteristics appear to explain only a small portion of conservation adoption behavior; institutional factors (e.g., farm programs, credit availability) probably are highly influential. Research on individual farm characteristics (e.g., size, specialization, land tenure) and farmer traits (e.g., age, education) and their relation to conservation adoption has yielded mixed results. Most researchers consider institutional factors to be much more influential, but few studies have been conducted on these to date (90).

Studies on adoption of farm practices have rarely examined the physical settings of adoption decisions or the extent of resource degradation as it relates to adoption of remedial farm practices. Although many adoption studies have tested individual and farm characteristics as potential variables influencing adoption of farm practice changes, few studies have included data on the farm's physical environment, including topography, extent of soil erosion, proximity to water bodies, and regional hydrogeology (100). As a result, sociological studies typically categorized farmers who did not adopt soil conservation practices as "non-adopters,' whether or not these farmers needed to reduce soil erosion in the first place. Thus, while agricultural specialists in the physical and natural sciences have tended to ignore social influences in technology adoption, social scientists have also tended to ignore nonsocial variables in their studies.

Farmers tend to underestimate the severity of soil and water quality problems on their own farms. Farmers tend to perceive that soil erosion and water quality problems are more severe at the national level than they are in their own counties. They also tend to perceive these problems as least severe on their own farms (111). This "proximity effect' indicates that farmers are aware of the need to protect soil and water in general but often underestimate the need on their own farms (103).

Farmers are most likely to adopt technologies with certain characteristics. Favored technologies are those that: 1) have relative advantage over other technologies (e.g., lower costs, higher yields); 2) are compatible with current management objectives and practices; 3) are easy to implement; 4) are capable of

being observed or demonstrated; and 5) are capable of being adopted on an incremental or partial basis. Diffusion research indicates that farmers are probably more likely to test technologies or practices that they think have these characteristics (128,113). Cropping systems approaches and Best Management Practice (BMP) combinations to reduce groundwater contamination are much more complex than individual BMPs or technological products. Complexity of systems-oriented changes will slow their adoption.

Decentralized information exchange among farmers promotes a wider range of innovations than do more centralized diffusion channels. Diffusion research indicates that local social networks are more important in the dissemination of preventive innovations than they are in incremental innovations (127). Due to the complexity of groundwater contamination problems, decentralized information exchange is likely to be very important in implementation of appropriate farming practices to protect groundwater. Groundwater quality improvements will require broad understanding of complex factors, knowledge of site-specific conditions, and trial-and-error in developing appropriate combinations of farming practices. These prerequisites cannot be readily achieved through centralized information mechanisms alone (77,75). Farming changes to protect groundwater will likely be facilitated by decentralized farmer-to-farmer information exchange (103).

In summary, decisionmaking research indicates that farmers are a heterogeneous group, whose decisions on agrichemical use and groundwater protection will be made based on their fundamental objectives for farming. Economic factors typically define what is financially possible for farmers, particularly in the short-term, but other personal, social, and environmental factors also influence decisionmaking. Institutional factors may be particularly important in farmers' decisions to implement resource-protecting practices, which are adopted more slowly than other types of innovations. Voluntary adoption of resource-protecting practices may be slowed due to farmers' tendency to underestimate the severity of resource degradation problems on their own farms.

FACTORS INFLUENCING AGRICHEMICAL USE AND GROUNDWATER PROTECTION

Farmers' decisions are shaped by their objectives, constraints, and opportunities. Different constraints and opportunities are associated with each of the four approaches to reducing agrichemical contamination of groundwater: agrichemical management to reduce point-source contamination, improving agrichemical application management, agrichemical use reduction, and use of nonchemical practices.

Risk

Farming is risky, subject to uncontrollable influences such as weather, pest infestations, and changing market conditions. Farmers who use agrichemicals know which crop yields and levels of pest control have been obtained in past seasons with tried-and-true application rates. Even though equivalent crop yields could be achieved by reducing agrichemical use, many farmers perceive that crop yields would be lowered if they did so (111). Alternatively, farmers may be aware that they are applying agrichemicals at higher-than-needed rates but are willing to pay for this yield "insurance" (118).

Before adopting a new practice, farmers need site-specific and pertinent information to compare costs and benefits of current v. other available technologies. In considering any change, farmers not only risk losing ''insurance' benefits of previous practices but they also incur the risk of trying a new practice, which may involve "learning costs" that are poorly quantified. This ''double risk' associated with adopting a new practice makes farmers reluctant to change practices without sufficient information and poses severe obstacles to reducing agrichemical use through use of alternative practices.

Farmers vary in their willingness to accept risks and benefits of agrichemical use, influencing the kinds of farming practices they are willing to try. Farmers willing to try alternative practices are more likely to be economic risk-takers than those less willing to experiment (46). Conversely, such farmers may actually be more averse than average to health and environmental risks.

Complexity

Farmers face greater risks and transition costs in decisions to use technologies or management practices that are more complex or greatly different from their usual practices (172). Agrichemical technologies, once incorporated into a farming system, have become relatively easy technologies to use, and they confer important benefits to farmers by reducing the time or labor needed to control pests or provide plant nutrients, compared to some nonchemical practices (tables 5-10 and 5-11). Thus, technologies that maintain these benefits at acceptable levels, that modify existing farming systems only incrementally, or that require little more than a new understanding are more likely to be voluntarily adopted than technologies requiring increased management, different skills, or major modifications to farming systems (e.g., different equipment).

Addressing point sources of agrichemical contamination is perhaps the least disruptive groundwater protection approach, because it implies that the farmer will continue to use agrichemicals but modify storage, handling, and disposal practices to minimize contamination, Convincing farmers who currently rely on conventional agrichemical techniques to invest in other management approaches that are more information- or skill-intensive is likely to require substantial information, documentation, and incentives. Farmers will need time, additional knowledge, and possibly technical assistance to plan, learn about, and gain experience with new practices to reduce groundwater contamination.

Lack of Information

Information serves to reduce uncertainty and helps close the gap between actual and farmer-perceived risks associated with resource-protecting technologies. Two types of information are needed in assisting farmers to reduce agrichemical contamination of groundwater and both types of information may be of limited availability to farmers.

First, the problem of agrichemical contamination of groundwater must be defined and specified to farmers, because farmers are not likely to consider farming practice changes until they first recognize that a problem is arising from current practices (103). Furthermore, farmers tend to perceive resource problems that are farther away from the farm operation as being more severe than resource problems closer to the farm operation (1 12,90). This implies that a critical component of groundwater-related information programs is the ability to provide site-specific problem definition. Although a site-specific agrichemical contamination problem can be identified by testing groundwater for contaminants, groundwater monitoring data are often unavailable in many areas, too costly to obtain, or too difficult for the farmer to interpret in terms of associated health risks or the economic losses from wasted agrichemicals.

Second, farmers need site-specific economic and agronomic information on practices that reduce agrichemical contamination of groundwater. Farmers are not likely to adopt alternative practices based on stewardship themes or vaguely defined health risks. Although these messages may motivate farmers to seek alternatives, there is low probability of adoption unless they can obtain adequate economic and agronomic information about suggested corrective practices. However, economic or agronomic

Table 5-10-Production Inputs for Nitrogen Management

Type of Input:
. Additional inputs needed for use
Soil nitrogen:
• Soil tests
• Information and planning to determine nitrogen credits
Commercial nitrogen fertilizers:
• information and planning to determine timing and rates
• Labor and time involved in application or payment for custom application services
• Application equipment investment or rental
• Fuel required for application
Legumes:
• Additional land for crop rotation
• information and planning to determine cropping sequence, crop mix, seeding rates, and cutting or plow-down times
• Legume seed
• Soil preparation and planting equipment
• Labor and time involved in planting, cutting, and plow-down
• Cutting, mowing, and plow-down equipment
• Fuel required for soil preparation, planting, cutting or mowing, and plow-down
Manures:
• information and planning to determine application sites and rates
• Manure source
• Manure hauling costs
• Manure storage site or facility
• Equipment for comporting or turning manure
• Labor and time involved in comporting or conditioning manure before application
• Nutrient analyses
• Manure spreading equipment
• Labor and time involved in manure spreading
• Fuel required for manure spreading

SOURCE: Office of Technology Assessment, 1990.

Table 5-11-Constraints To Reducing Herbicide Use

Constraint	Possible solutions
Lack of equipment to replace herbicides with mechanical cultivation (rotary hoe, disk hillers, etc.)	Low-interest loans for equipment purchase
Unpredictability of spring weather, which can make soil *too* wet for mechanical cultivation	Use of mechanical cultivation when weather permits; use post-emergent herbicides when weather too wet for cultivation
Lack of time to cultivate fields	Contractor services
Lack of skills in using nonchemical weed control methods	Extension programs; contractor services
Increased use of herbicides for conservation tillage	Extension information and demonstration on herbicide use for conservation tillage; Extension surveys to monitor herbicide use
Field equipment that spreads weed seeds	Technical assistance to design and retrofit equipment (e.g., combines) to capture weed seeds
Lack of information on weed seed populations	Weed seed measurements; computer software to calculate herbicide use on basis of weed seeds; contractor services

SOURCE: Office of Technology Assessment, 1990.

Photo credit: U.S. Department of Agriculture, Agricultural Research Service

State agricultural scientists and Cooperative Extension Services offer assistance to farmers on improving nutrient and pest management. Here, Iowa State researchers examine a soil sample which will be tested for nitrates and organic matter.

facts may not be presented in accessible or usable formats for the farmer. The right type of information in the appropriate format needs to be made available to the farmer at the stage of the decision process when that information is relevant (103).

Of the four approaches to reducing groundwater contamination, more information is available on reducing point-source contamination and improving agrichemical application management than on use reduction or nonchemical practices. For many farmers, point-source controls and improved agrichemical application techniques are easier to implement than extensive farming practice changes, because these approaches allow farmers to continue to rely on their own experience and knowledge with agrichemical-based techniques. Information on more complex farming practice changes is not as extensive or readily available. Many farmers interested in reducing agrichemical use through low-input, sustainable, or organic cropping systems have stated that the Cooperative Extension Service (CES) is an inadequate information source on these approaches (103, 140). Instead, these farmers have sought information from other farmers experienced in these approaches, and informal groups of farmers have emerged to find viable methods of reducing agrichemical inputs (103). Such farmer-to-farmer information and assistance networks confirm the observation that individual farmers are important both as sources and evaluators of information (78). Thus, farmer-to-farmer transfer can play important roles in disseminating information on more complex farming system changes to reduce groundwater contamination by agrichemicals.

Lack of Documented Research

Farmers are more likely to adopt technologies that have proven, documented results. The performance of farming practices to protect groundwater will have to be evaluated in two areas: 1) farm profitability in the short and long term; and 2) improved groundwater quality. Documentation in both areas will require baseline data collection and recordkeep-

ing. Demonstrations and financial analyses showing yield maintenance or improvements, cost reductions, or higher net returns from farm practice changes are more likely to convince farmers to try them.

Although anecdotal evidence exists of the profitability of alternative practices at the individual farm level, it is difficult to determine whether the profitability results from reductions in purchased inputs or from better management (10). More research is becoming available on the profitability of crop rotations, such as in east-central Nebraska, where rotation systems were observed to have higher average net returns than continuously cropped systems (59). Nevertheless, useful economic analyses of the cost-effectiveness of alternative practices cannot be obtained unless farmers keep accurate records of all nutrient and pest control inputs, including time, labor, and management requirements. Demonstration projects will be more effective if they provide assistance in farm recordkeeping.

Difficulty in Demonstration

Groundwater quality improvements will be more difficult and expensive to demonstrate than farm profitability, because groundwater quality changes can only be evaluated through long-term monitoring. Of the four approaches to protecting groundwater, farmers are most likely to implement agrichemical storage and handling improvements, recognizing that these practices address obvious point sources. Point-source controls also lend themselves more readily to regulatory oversight through construction specifications, permits, and maintenance and calibration checks.

On the other hand, farmers are less likely to assume that changing farm practices in the field will reduce nonpoint-source contamination. Given the lag time before groundwater quality improvements can be demonstrated through monitoring, farm records showing fertilizer and pesticide reductions may provide the only information on which to evaluate possible groundwater impacts. Farmers in hydrogeologically vulnerable areas who receive assistance to change their practices would need to keep good records of the types, amounts, and locations of pesticide and fertilizer use.

DECISIONMAKING TO PROTECT GROUNDWATER

Farmers have available a range of practices under four general approaches to reduce groundwater contamination by agrichemicals. However, practices under the first two approaches, ***reducing point-source contamination*** and ***improving agrichemical application,*** **draw** from a larger information base, employ well-established information sources such as agrichemical dealers and the CES, and are perceived to be less risky and easier to implement. Practices falling under the latter two approaches, ***we-reduction*** and ***nonchemical alternatives,*** on the other hand, are perceived as more risky, although some established information sources are providing more documentation on these practices' impacts on yields and net returns. Nonchemical practices may be the most complicated and riskiest types of practices to implement, because they have a less-developed research base, and information on them tends to be disseminated through less well-established sources such as farmer networks.

Which technologies, if any, ***should*** farmers adopt in response to groundwater contamination concerns? Which technologies ***can they*** adopt, given current economic and institutional constraints? Which technologies ***will they*** adopt? Four conditions are prerequisites for planned change to occur within a target population, and these can be applied to the problem of groundwater protection in agriculture:

. knowledge of the problem and of potential solutions;
- perception of a need to solve the problem;
. ability to commit resources to solve the problem; and
- access to sufficient resources, skills, and time to implement solutions (179).

Groundwater protection strategies that achieve these four prerequisites are more likely to reduce agrichemical contamination of groundwater by facilitating farmers' decisions to take groundwater-related actions.

Knowledge of Agrichemical Contamination of Groundwater

The people who will be most directly affected by groundwater protection policies for agriculture are people who work and live on farms (68). Landowners, farm managers, and farm workers will be

responsible for implementing changes in farming practices and will most directly bear the economic costs of any changes. Farm residents also will derive the most immediate benefits from any resulting improvements in drinkingwater quality. Farm residents are more likely to be exposed to any hazards of contamination, because farmstead drinking water wells are closest to sites of groundwater pollution and agrichemical concentration in groundwater is greatest near the source of pollution.

Farmers are highly aware of agrichemical contamination of groundwater (see box 5-E). However, they may not be sufficiently convinced of the severity of the problem or of the efficacy of ‘‘corrective’ farm practice changes to take action. Before farmers undertake farm practice changes, they are likely to consider a multitude of questions, for example:

- Is the groundwater beneath *my* farmland contaminated by agrichemicals?
- How does contamination affect the safety of my family’s and other people’s drinking water supplies?
- Have my farming practices or agrichemical management methods caused this contamination?
- What will it cost to reduce contamination, in time, labor, money, and crop yields?
- If I change practices, how will I know if these changes really do reduce contamination and any attendant hazards?
- Will I be liable for any hazards associated with my farming practices?

Many farmers believe that a groundwater contamination problem exists overall, but they are likely to want specific evidence that a problem exists on their own farms. Information on regional hydrogeologic vulnerability is a starting point, but this must be supplemented by local well testing, groundwater monitoring results, and evidence linking farm practices to groundwater contamination in their areas.

Need To Reduce Agrichemical Contamination

Farmers will consider groundwater protection a priority only if they perceive a real need for it. Possible motivations for farmers include:

- confirmed high hydrogeologic vulnerability of farm site (e.g., sandy soils, high water table, karst area);
- high nitrate levels or pesticide detections in drinking water well;
- evidence linking on-farm point sources to groundwater contamination;
- evidence linking farm practices to groundwater contamination (e.g., application rates in excess of crop needs);
- evidence of lost dollars due to wasted agrichemicals or costs of excess agrichemical applications;
- high level of personal or family health concerns;
- high level of concern about adverse impacts on the farming system or environment;
- liability concerns due to community or neighbor complaints;
- existence of regulations and penalties; and
- impending pesticide bans or restrictions.

Farmers’ main motivations to reduce groundwater contamination will be personal health concerns, liability, and need to reduce costs from wasted agrichemicals. These motivations, however, must outweigh constraints imposed by risk aversion; fear of yield reductions; lack of time, skills, or appropriate equipment; and perceived high costs of farm practice changes.

Ability To Commit Resources To Reduce Groundwater Contamination

Farmers’ ability to respond to groundwater contamination problems or comply with increased environmental restrictions will greatly depend on their farms’ financial conditions, which vary within and between farm types (e.g., field crops, specialty crops, livestock) and sales classes (see box 5-F). Farmers with high debt-to-asset ratios and negative cash flows in all sales classes will be less able to commit resources for environmental controls (165). Although financial impacts will depend on the type of farm pollution controls needed, smaller farms may experience the greatest financial constraints, because these farms typically have fewer financial resources overall. Point-source controls requiring large initial capital outlays would be most likely to impose financial constraints on farms in smaller sales classes. However, farm practices to reduce nonpoint-source contamination may be easier to implement for smaller farms and larger farms with low cropland use intensity.

Box 5-E—Farmer Awareness and Concerns About Groundwater Quality

An understanding of farmers' attitudes toward groundwater contamination by agrichemicals is important in anticipating reactions to policy alternatives. In the fall of 1988 OTA commissioned a review of emerging literature on farmers' general attitudes toward agrichemicals and groundwater quality, and preferences for policy responses to the issue (1 11). AU major studies identified in the review had been conducted within the last 5 years, with the most relevant ones reported within the last 2 years. Substantive data from 14 States[1] were obtained, but studies varied considerably among States in the areas covered by the surveys. Most of the studies were descriptive in nature and were not used to draw statistical conclusions. Because of variation in survey methodology, only some of the data could be aggregated to make comparisons.

More surveys had been completed in cash grain-producing regions of the Midwest, particularly in Iowa and Wisconsin, where groundwater quality has become an issue of public concern and debate. At the time of the analysis, no studies had been identified from the western region and only a few from the southern region. These geographic information gaps preclude any generalizations about farmers' attitudes on a national basis. Despite data limitations, these studies provide insights into attitudes of surveyed farmers, particularly where the issue has been given greater attention by the media.

Importance of Drinking Water Quality-Surveys of farmers in Iowa, Minnesota, and Virginia clearly indicate that these farmers attach a great deal of importance to drinking water quality (63,76,108,110,33,54). When farmers were asked to rank drinking water quality among a series of issues, the general pattern was for farmers to rate water quality as slightly less important than profitability or economic well-being. Data also suggest that agrichemical and groundwater quality receive greater importance when posed as health issues rather than environmental ones. Greater health concerns have been expressed for pesticides than for nitrate. Findings from the above studies consistently indicated that surveyed farmers consider agrichemicals to be a major contributor to groundwater pollution.

Attitudes About Seriousness and Proximity of Groundwater Contamination Problem—Although surveyed farmers considered groundwater contamination by agrichemicals as 'serious, " they tended to view the problem as more serious for people in other areas and less serious on their own farms. The policy implications of this tendency are that educational programs alone are not likely to provide sufficient motivation for farmers to change their practices. Farming practice changes may not occur unless farmers can be shown specific evidence of the extent and degree of groundwater contamination on their own farms.

Attitudes Toward Benefits-Costs of Agrichemicals-Statewide surveys of over 300 randomly selected New York farmers and nearly 600 Iowa fanners indicated that the majority-as high as 80 percent in Iowa—would like viable alternatives to agrichemicals (17,112). Even though these studies indicate that farmers want alternatives, chemical use remains widespread. Studies among row crop grain farmers have found that the majority believe pesticides are their best current alternative to control weeds, pests, and plant diseases. Studies in Wisconsin, Iowa, California, Florida, and Pennsylvania indicate that the majority of farmers believe that they have already reduced agrichemical use as much as they profitably can. These majority percentages ranged from 65 and 66 percent in Iowa and Wisconsin to a high of 80 percent in Florida (177,112,35).

In the Wisconsin statewide survey, 71 percent of the farmers felt their yields would drop if chemical inputs were reduced The Iowa statewide survey showed half the respondents stating that increased costs for tillage, labor, and machinery would cancel any savings from herbicide reductions. When asked their opinions about health and environment concerns associated with agrichemical use, farmers in Iowa, Minnesota Virginia, Oklahoma, and New York were split fairly evenly between those agreeing and disagreeing with the idea that significant health and environmental threats exist (109,1 10,33,54,89,17). Thus, despite divided opinion about health and environmental impacts, farmers justify their use of chemicals from an economic decisionmaking framework.

Relationships Between Attitudes and Intensity of Agrichemical Use—In a survey of about 570 farmers in North Carolina, full-time farmers with more agrichemical-intensive operations expressed significantly less concern about whether the products might be harmful to wildlife than farmers with less chemically intensive

[1]California, Florida, Georgia, Indiana, Iowa, Massachusetts, Minnesota, Mississippi, New York, North Carolina, Oklahoma, Pennsylvania, Virginia, and Wisconsin.

operations (7). Similarly, studies in Iowa and Virginia revealed that farmers who applied high levels of nitrogen fertilizer consistently saw agrichemicals as significantly less of an environmental problem than farmers who applied lower levels (54,108). The policy implications of these findings are that intensive users of agrichemicals may be less motivated to reduce agrichemical use than less intensive users, even though their practices have greater potential to contaminate groundwater.

In summary, survey findings indicate there is general awareness among farmers of the groundwater contamination issue in areas where groundwater quality has received public attention. However, farmers are suspicious, but uncertain, about the true health risks associated with agrichemicals. There *seems* to be a lack of motivation for personal action, in part because farmers do not acknowledge a serious problem on their own farms. This may be either genuine nonrecognition or a lack of concern about a potential problem. Whichever the case, in the absence of specific knowledge about one's own drinking water or documented associated health problems, voluntary change is not likely to occur on a widespread basis.

If the problem is genuine nonrecognition, education and assistance could have an important impact, and farmers have reported that such evidence would be motivation for them to change. Since many private wells are not regularly tested, particularly for pesticides, monitoring programs in hydrogeologically sensitive areas would provide important information and bases for motivation. Another impediment to voluntary change may be beliefs or knowledge about alternatives. Survey findings indicate that farmers are willing to consider alternatives to agrichemicals. At present, however, most farmers believe that pesticides are their best tools against insects, weeds, and plant disease and that they have already reduced their chemical inputs as much as they economically can. Thus, by fostering attitude change it may be possible to encourage farming practice changes. Farmers appear to be open-minded but not fully convinced of the true seriousness of the problem or of the viability of current alternatives.

Farmers' ability to respond to environmental concerns also will depend on trends in the agricultural sector, such as increasing concentration of farmland among larger farms, ownership arrangements, and contract obligations (see box 5-B). For example, tenants and partial owners, who managed about two-thirds of all farmland in 1982 (table 5- 12), may be less willing or able to invest in groundwater protection practices on rented land than farmers who fully own their land. Thus, a farm operator's ability to achieve changes in groundwater quality will depend on the extent of change needed, incentives and freedom to make changes, and the farm's financial and management capacity to accommodate farm practice changes.

Access To Resources and Technical Assistance To Achieve Solutions

Farm size and financial condition will affect farmers' ability to commit resources, but their ability to achieve real improvements in groundwater quality probably will require technical, administrative, and financial assistance. A variety of groups can participate in assisting farmers to reduce agrichemical contamination of groundwater, including State, local, and Federal agencies providing assistance at the farm-level. Increasing farmers' access to resources and assistance will depend on available Federal, State, and local funding used to identify groundwater problems and solutions and on a clear definition of agency roles in providing technical assistance.

TECHNICAL ASSISTANCE TO REDUCE AGRICHEMICAL CONTAMINATION OF GROUNDWATER

Agricultural producers receive information and technical assistance from a variety of sources when making decisions about crop selection, nutrient and pest control inputs, and soil and water management (table 5-13). Private-sector information sources include agrichemical manufacturers, dealerships, farm cooperatives, crop consultants, agricultural magazines, and radio and television advertising. Public-sector sources include Federal, State, and local agencies and organizations. The most frequently used sources of agrichemical information are agrichemical dealers, although many producers perceive CES to be the most reliable source (1 12). Pesticide labeling and agricultural publications also are important information sources for the farmer. Although formal information sources play important

Box 5-F—Implications of Farm Size for Technical Assistance

Farm size is typically measured by the annual gross market value of agricultural commodities produced per farm (153). Farm size reflects the magnitude of a farm's financial resources and is likely to influence farmers' risks and abilities to change production practices. Farm size and financial status thus are relevant in designing appropriate technical assistance strategies that encourage changes in nutrient and pest management. The following table shows one classification of U.S. farms based on annual gross sales and indicates the percentages of total farmland area covered by farms in different sales classes in 1987.

Sales class	Value of farm products sold per farm	Average farm size (acres)	Farmland area in sales class (1,000 acres)	Percent of total farmland area
Small, part-time	>$20,000	148	220,573	20,7%
Part-time	$20,000-99,999	689	340,885	34.0
Moderate	$100,000-249,999	1,278	250,650	25.8
Large and very large	2$250,000	2,304	190,650	19.5
Total			1,002,603	100.0

SOURCE: U.S. Department of Agriculture, "Table 533: Percent of Farms, Land in Farms, and Average Aize, by Economic Class, United States, 1987," *Agricultural Statistics* 1988.

Although these data aggregate all types of farms (crop and livestock) and fail to distinguish regional variations, they are still useful in showing the extent of land area managed as farms in different sales classes overall. For example, a significant proportion of the Nation's farmland (roughly 55 percent) was managed as small or part-time farms in 1987. Overall potential for different-sized farms to contribute to nonpoint-source groundwater contamination (therefore determining their need for assistance) will depend on farm locations relative to hydrogeologically vulnerable areas, extent of farmland involved, commodities produced, and intensity of agrichemical use.

Farm size also affects the financial status of the farm and the need for off-farm income. The following table gives aggregate national data on farm income by sales class in 1987.

Sales class	Value of farm products sold	Average net farm income	Average off-farm income	Average total income
Small, part-time	>$20,000	$ -323	$24,000	$23,677
Part-time	$20,000-99,999	13,000	17,0i)o	31,074
Moderate	$100,000-249,999	51,749	14,383	66,132
Large	$250,000-499,999	128,678	16,090	144,768
Very large	2$500,000	738,132	29,363	767,495

SOURCE: U.S. Department of Agriculture, Economic Research Service, "Table 37: Average Net Farm Income Before Inventory Adjustment Per Agricultural Operation, by Value of Sales Class," and "Table 40: Average Off-farm Income Per Agricultural Operation, by Value of Sales Class," *Economic Indicators of the Farm Sector, National Financial Summary, 1987,* October 1988.

Again it should be noted that these aggregated data do not characterize regional or local trends, because the distribution of farms among different sales classes varies by region and commodity. Also, per-farm statistics by sales class should not be interpreted as per-farmer statistics, since more than one operator may share in production risk per farm, particularly in the larger sales classes (153). Nevertheless, these data provide a useful context for understanding general income trends and potential decisionmaking constraints to groundwater protection:

Small Farms—Farms with gross sales of less than **$20,000** per year generally do not provide a significant source of income to their operators. Most farm operators in this class obtain their primary net income from off-farm sources. Average net farm income for this sales class in 1987 was negative, with off-farm income averaging $24,000. The small farm subsector, however, is not homogeneous—it contains a large number of subsistence farms whose operators live at or below the poverty level as well as a large number of affluent families to whom the farm is more a form of recreation than a source of income. One in five farm operators in this sales class in 1982 was a full-time operator (138). Fifty-eight percent of this group were part-time farmers working 100 days or more per year off the farm. The remaining farmers were full- or part-time farmers over the age of 65, Part-time operators, who include individuals using the farm as either a tax shelter or for recreation, had the highest total incomes in this sales class because of their off-farm employment.

Although small farms constitute 21 percent of total farmland, the percentage of agrichemical-treated farmland covered by small and part-time farm operations may actually be lower. Small farms involving livestock or recreation are likely to be less agrichemical-intensive than farms producing commodity or specialty crops. Since small-farm operators historically have taken less advantage of technical assistance programs than have large-farm operators, small farms located in hydrogeologically vulnerable areas may require more intensive outreach efforts. Also, technical assistance to small

farms would need to be tailored to their financial and time constraints (180). Small farms are also more likely to need low-cost technologies or financial assistance to reduce groundwater contamination. Any increases in net income resulting from more efficient agrichemical use would benefit small-farm operators to a proportionally greater extent than large-farm operators.

Part-time Farms-Farms with annual gross sales between $20,000 to $100,000 may produce significant net income but are typically operated by people who depend on off-farm employment for their primary source of income. Because net farm income is low and off-farm income tends to be lower than average, farms in this sales class are likely to experience financial difficulties. Moreover, part-time farmers who work 40 hours a week at an off-farm job have only about 43 percent of their time available for farming(99).

If recent trends continue, part-time farms could increase in number, but this will require the families living on these farms to earn the bulk of their income from off-farm sources. Part-time farmers may rely heavily on agrichemical use to save time and labor, which would make it difficult for them to adopt farming practices requiring more time and management. Part-time farmers thus are likely to experience greater time constraints to reducing agrichemical use. On the other hand, part-time farmers may be more willing to make changes in their farm practices simply because their principal income is derived off the farm, allowing them to undertake some potentially risky activities in their farming ventures.

Moderate-sized Farms-Farms that generate more than $100,000 in annual gross income are generally capable of supporting full-time operators, and commonly require labor and management from at least one full-time manager. Average off-farm income in this sales class is lowest of all classes, but the net income of moderate-sized farms is decreasing in absolute terms and in terms of their share of total farm income (144).

In upcoming years, moderate-sized farms are expected to decline in number if they are not able to increase farm income or obtain more off-farm income. Moderate-sized farms are most prevalent among cash grain, hog, and dairy operations in the North-Central and Northeast regions. Many moderate-sized farm operators have been under severe pressure in the 1980s to increase yields to offset reductions in farm prices. One strategy has been to produce more commodities by expanding or renting more land; another is to intensify use of agrichemicals. Many of these operations use high levels of agrichemicals to maintain productivity. Under voluntary programs to reduce groundwater contamination, operators of these farms are likely to implement only those farm practice changes that maintain or increase net returns.

Large and Very Large Farms—Farms with annual gross sales greater than $250,000 are maintaining or increasing their shares of farm income. As a group, the households that own and operate these farms have moderate off-farm incomes and moderate-to-very large net farm incomes. Most farms in this class require one or more full-time operators, and many depend on hired labor on a full-time basis to manage their larger land areas. Five percent of these farms in 1982 were owned by nonfamily corporations, thus involving more than one owner in decisionmaking. This will mean that some agreement has to be reached among owners and managers in deciding whether to implement farm operation changes related to groundwater protection.

The amount of farmland managed by large and very large farm operations is expected to increase beyond the present 20 percent of all farmland with the continued trend toward concentration in the agricultural sector. Farms in these sales classes are projected to account for about 15 percent of all farms by 2000, or three times their proportion in 1982 (144). Changes implemented on large farms would have relatively high environmental impacts, because management changes per farm would affect a large acreage. Since large and very large farms will probably continue to produce the greatest shares of commodities in the United States, incentives aimed at large farms would affect larger land areas on which the majority of commodities are produced.

Larger farms historically have adopted conservation methods to a greater extent than smaller farms, because large farms have more financial resources and contacts with local extension and conservation agencies (149). Large farms with greater financial resources are probably more capable of making financial adjustments to accommodate farm practice changes without government assistance. However, the need to capture returns from previous capital investments in production systems could discourage large farms' adoption of practices to reduce groundwater contamination.

Policy Implications-Farm sizes and sales classes have implications for the amounts and types of technical assistance local farmers are likely to need to improve the quality of local natural resources. Small and part-timefarmers are more likely to experience financial and time constraints in making farming practice changes to reduce agrichemical contamination of groundwater, while large farmers are more likely to want to continue using practices in which they have invested large amounts of capital. State and local programs to reduce agrichemical contamination of groundwater have better chances of being effective if they are built on a good understanding of the local structure of agriculture and likely constraints which could interfere with local resource protection efforts. Thus, State and local governments could consider local and regional distributions of farms among small, moderate-sized, and large sales classes when developing and implementing groundwater protection programs.

Table 5-1 2—Land Ownership and Tenancy: Number of Farms and Land in Farms, 1982

Land tenure classification	Number of farms	Percent of farms	Farmland acres (thousands)	Percent of farmland
Fully owned	1,321,000	59	345,379	35
Fully rented	269,000	12	108,547	11
Part-owned/rented	649,000	29	532,870	54
Total	2,239,000	100	986,796	100

SOURCE: Compiled from U.S. Department of Agriculture, tables 535 and 536, *Agricultural Statistics* 1988, based on data from U.S. Department of Commerce, Bureau of the Census, the 1982 Census of Agriculture.

Table 5-13--Sources of Information and Technical Assistance to Farmers on Agrichemical Management

	Role
Public sector:	
State Cooperative Extension Service (C ES) specialists and agents	Information on production techniques and farm management; pesticide applicator training; soil testing services
USDA Soil Conservation Service (SCS)	Technical assistance on soil and water conservation and resource management planning
USDA Agricultural Stabilization and Conservation service (ASCS)	Financial assistance for soil and water conservation, integrated crop management, farm program participation
State Department of Agriculture	Pesticide applicator certification
State Departments of Health; Natural Resources; or Environmental Quality	Well water monitoring and testing; well construction standards
Private sector:	
Farmer cooperatives; agrichemical dealers and suppliers	Sales and service of production inputs; product selection and application rate recommendations
Agrichemical manufacturers	Pesticide labeling information; training programs and educational materials
Advisory and technical service firms	Soil testing; pest scouting; computer services
Agricultural media	Production information and product advertising
Farm commodity purchasing firms	Production requirements or quality standards
Other farmers (neighbors; commodity groups; farmer-to-farmer referral groups)	Advice, observation, and experience on production techniques
Agricultural management firms and consultants	High-management production services

SOURCE: Office of Technology Assessment, 1990.

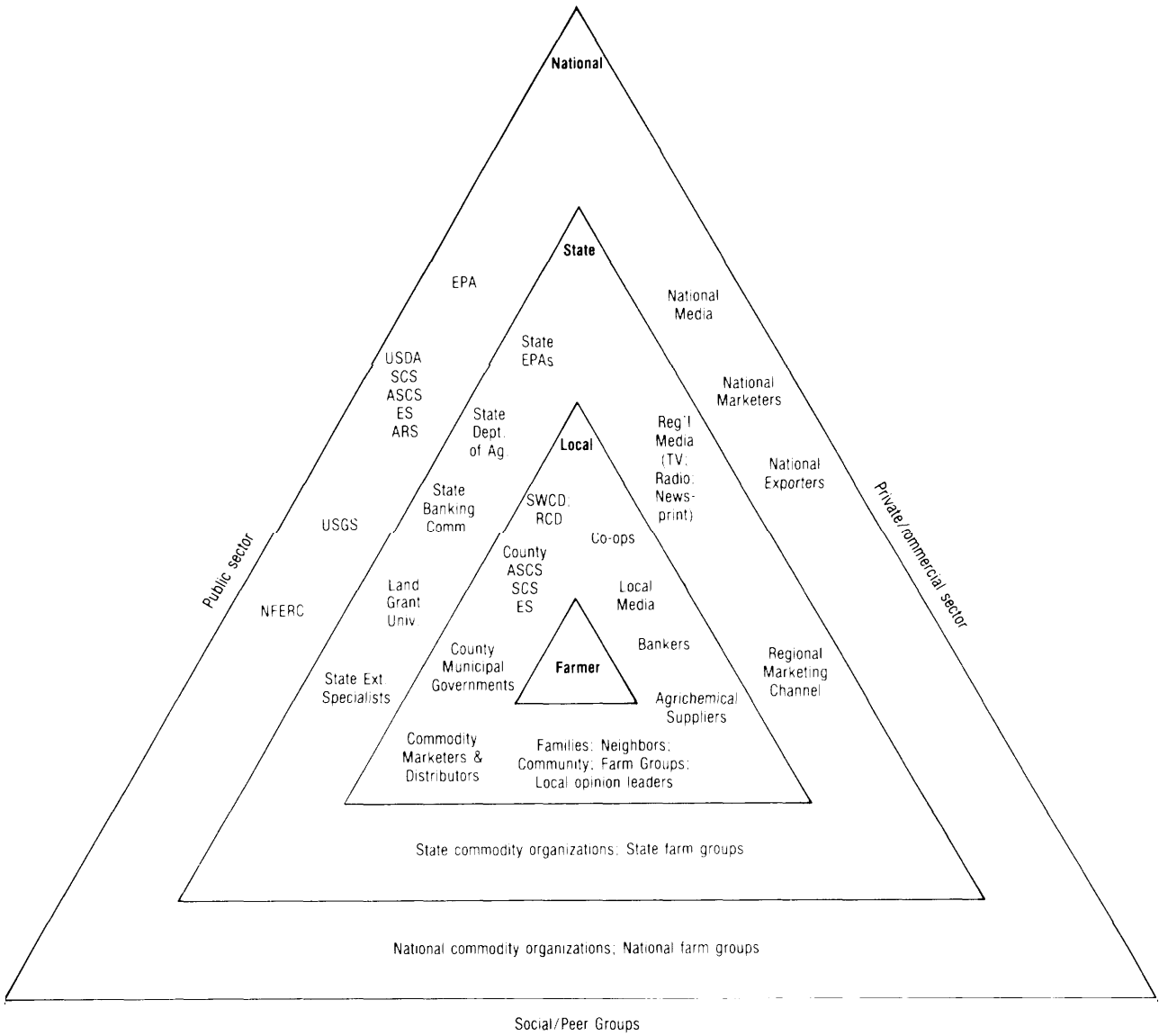
roles in influencing farmers' decisions, farmers also obtain guidance from numerous informal contacts with other farmers, family members, landlords, lenders, other business people, and local residents. The opinions and choices of these other individuals and organizations also inform and motivate farmers (figure 5-4).

Most farmers face ''a situation of information overload rather than information deprivation' (102). Information flow to and among farmers is a competitive process, and farmers must pick and choose among diverse sources of information and assistance. If farmers hear consistent messages from public, private, and informal information sources regarding the importance of proper agrichemical use and resource protection in agriculture, they will be much more likely to implement practices that protect groundwater.

Public-Sector Assistance—Federal Agencies

Two Federal agencies are structured to provide routine assistance to farmers at the local level—USDA's Soil Conservation Service (SCS) and Agricultural Stabilization and Conservation Service (ASCs). Several other agencies and offices within the USDA, EPA, and the Department of the Interior contribute to research, monitoring, and technical assistance related to agriculture and groundwater, but these agencies do not assist individual farmers through local offices (figure 5-5). Administrative and technical guidance offered by field offices can predispose farmers toward certain farming practices, and Federal assistance at the local level can facilitate

Figure 5-4--Socioeconomic Support Systems for Farmers Influencing Their Decision making



Sources of information for, and thus of influence on, farmer decisionmaking are numerous and some may be providing conflicting advice. Examples of influential groups affecting farmer decisionmaking include public agencies, private-sector groups, and social or peer groups at local, State, and national levels.

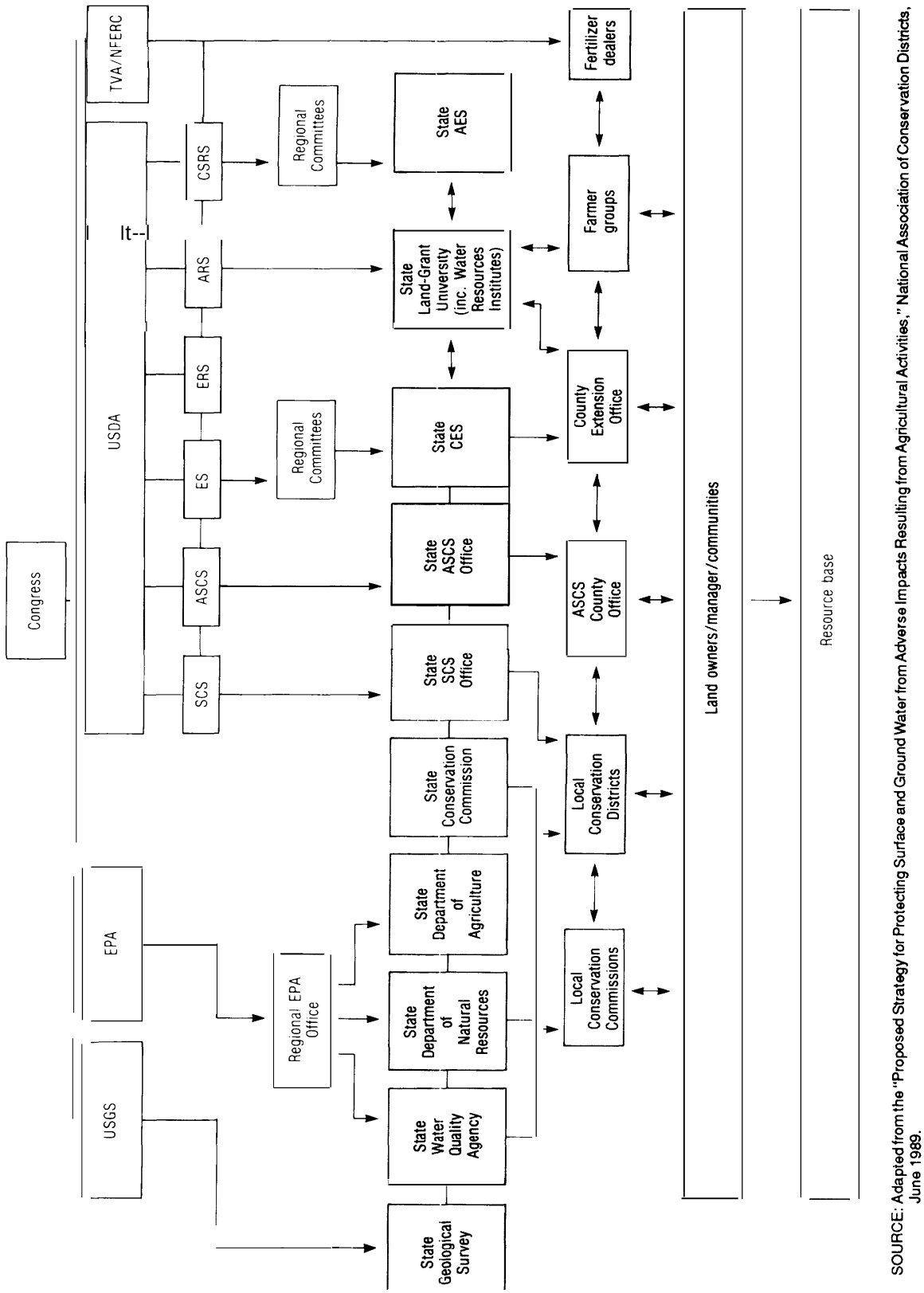
SOURCE: Office of Technology Assessment, 1990.

farm practice changes to reduce groundwater contamination.

USDA Soil Conservation Service

The SCS was created in 1935 to 'provide national leadership in the conservation and wise use of soil, water, and related resources' (160). SCS offers technical assistance to individuals, groups, and governments through SCS offices in local conservation districts. SCS State Conservationists, who answer directly to the national SCS Chief, head State-level SCS offices and are the primary SCS contacts for State interagency efforts. SCS offices at the State- and district-levels are coordinated as Federal agency components, in contrast to CES and State Agricultural Experiment Stations (SAESs), which are administered as State organizations. State-level SCS offices typically receive input on funding priorities and preferred management practices from conservation district representatives.

Figure 5-5—Federal, State, and Local Organizations With Roles in Protecting Surface and Groundwater From Agricultural Impacts



SOURCE: Adapted from the "Proposed Strategy for Protecting Surface and Ground Water from Adverse Impacts Resulting from Agricultural Activities," National Association of Conservation Districts, June 1989.

SCS District Conservationists assigned to field offices receive general guidance on conservation planning policies and procedures from SCS's National Conservation Planning Manual. Specific technical guidance, on the other hand, is provided through Field Office Technical Guides (FOTGs) developed at the State level. FOTGs provide guidelines on conservation and resource management practices that correspond to local land use needs and agricultural production conditions. The SCS planning process is designed to help landowners ''define natural resource problems, determine alternative solutions, choose among cost-effective solutions that are consistent with their objectives, and implement solutions as rapidly as is feasible and practical"(160).

SCS conservationists help land users develop soil conservation plans based on soil surveys, topographical maps, and FOTG guidelines, They also encourage land users to implement conservation practices and structures (e.g., terraces) by helping them obtain cost-share financing through the Agricultural Conservation Program (ACP). ACP payments for approved conservation practices are made through local ASCS offices. Although SCS technical assistance has traditionally emphasized soil erosion control, its scope has expanded to address additional resource concerns, such as protecting water quality and quantity, managing grazing lands and forests, and preserving wildlife habitat. SCS initiated a water pollution control effort in 1981 and has begun to address agrichemical contamination of groundwater as a component of this effort.

''Progressive conservation planning' is a concept developed by SCS to encourage land users to go beyond adopting single conservation practices to implementing a full set of practices and land uses for resource protection (122). SCS conservationists can help land users plan Resource Management Systems (RMSs), which are coordinated sets of conservation practices and management techniques designed to address the entire range of resources (e.g., soil, water, air, plant, and animal) specific to a farm or land use. SCS technical staff at the State level develop RMSs for field offices. Some groundwater-related materials have been developed for use in conservation and RMS planning. These include:

. local soil and site information, ratings on likelihood of nitrate leaching, pesticide characteristics and soil-pesticide interactions;
- water resource data and effects of land use, management, and conservation practices on water resources;
- standards and specifications for practices to protect water quality, including nutrient and pesticide management standards;
- water quality policies and regulations at national, State, and local levels;
- planning guidelines and criteria to develop RMSs that incorporate water quality concerns (160); and
- economic, environmental, and social trade-offs which the farmer can use to evaluate conservation options and water quality impacts (161).

SCS water quality and RMS materials, however, may not be consistently or fully utilized throughout all SCS field offices. Since State Conservationists are responsible for the "development, quality, coordination, use, and maintenance' of FOTGs used throughout their States (162), deployment and full application of these materials may depend on strong administrative support from State Conservationists. In addition, fuller implementation of comprehensive conservation planning assistance will depend on the motivation and training of individual conservationists and their ability to devote the time needed in advising and motivating landowners to pursue RMS development. Thus, SCS's role in assisting farmers to reduce groundwater contamination could be enhanced through clear Federal and State directives on groundwater protection as a component of conservation planning; full implementation of RMS and water quality materials in all field offices; and employee training on the use of these materials.

In 1985, Congress made SCS responsible for implementing the conservation cross-compliance provisions of the Food Security Act (FSA). The FSA directs SCS to develop "conservation compliance" plans by 1990 for all farmers having highly erodible lands who want to retain eligibility for Federal farm program payments. FSA conservation compliance requirements have nearly doubled the number of farmers using SCS assistance, currently estimated at about 1.5 million (122). SCS will continue to assist farmers on cross-compliance implementation in upcoming years, since conservation compliance plans must be fully implemented by 1995. Conservation compliance plans, however, constitute neither full conservation plans nor RMSs, and they have often incorporated weakened regulations on ''Alter-

native Conservation Practices, which permit higher levels of erosion than those called for in the original FSA legislation. Although FSA statutory requirements have increased the number of farmers seeking assistance from SCS, they have not necessarily fostered comprehensive conservation planning, because conservation compliance plans solely address erosion control on highly erodible lands.

Congress is considering further cross-compliance provisions involving agrichemical management planning to protect groundwater. If such legislation is passed, SCS will also likely be responsible for assisting farmers in developing agrichemical management plans. Policymakers will need to take into account key implementation issues in developing such provisions. SCS's current staffing and technical capabilities will need to be increased and expanded tithe agency is to implement agrichernical-related planning, because the agency's traditional expertise is in soil and water management. Clear goals and directives will also be needed, because local interpretation and flexibility in implementing management practices may make it difficult for SCS management plans to lead to significant reductions in groundwater contamination.

Agricultural Stabilization and Conservation Service

ASCS administers and distributes all Federal farm program payments to farmers who apply for programs at county ASCS offices. ASCS thus provides administrative and financial assistance to farmers, including ACP cost-share payments for implementing conservation practices. Local committees are responsible for approving the types of conservation structures and practices that are eligible at the local level for conservation cost-share payments.

ASCS's specific role in improving agrichemical management is through its current pilot cost-share project, Integrated Crop Management (ICM), which has been approved as an ACP practice. Impartially pays for consultant and scout services used by farmers to improve nutrient and pesticide management, up to $7/acre for field crops and $14/acre for specialty crops (151). The ASCS program will be tested in up to five counties in each State in 1990 and aims to achieve a 20 percent reduction in agrichemical use among participating farmers. If successful, the ICM program is likely to spur development and increase availability of field advisory services.

Public-Sector Assistance-State and Local Agencies

Information and assistance from State and local agencies complement Federal Government assistance and may be highly influential in farmers' decisionmaking. Although State and local governments vary widely in their organizational structures, decisionmaking committees, and roles of departments providing assistance to farmers and other landowners, some commonalities exist. Each State has a land-grant university with an associated CES and SAES to conduct research, education, and extension for the State's farmers. The land-grant university system thus is the primary public-sector source of information on agricultural production, agrichemical use, and agricultural resource management, including water quality. Each State also has a network of SCS district offices providing assistance to landowners on soil and water conservation. Although district offices advise farmers on conservation-related crop rotations and nutrient management to improve water quality, they have not been as heavily involved as CESs in agrichemical management assistance. In some States, other departments and agencies may play important roles in facilitating farmers' access to technical assistance.

Cooperative Extension Service

State CESs play the most important role in public-sector delivery of information and assistance to farmers, whose primary CES contacts are county or area extension agents in local offices and specialists at the land-grant university or experiment stations. CESs nationwide currently receive about 50 percent of their funding from State governments, 30 percent from the USDA Extension Service (ES), 17 percent from county governments, and 3 percent from private sources (48). As a result, CES program priorities are influenced most heavily by State needs and concerns, which may be identified by extension users and advisory groups, land-grant university administrators, and State legislatures. Priorities set at the national level (e.g., by the national Extension Committee on Organization and Policy are nonbinding and may be less influential than State needs in affecting CES activities) (142). Regional committees formed by CESs in the four extension regions (Northeast, South, North Central, and West) may also set priorities for extension programs which address regional needs more specifically.

Reduced funding in recent years has forced many State CESs to cut staffing levels, particularly at the county level. Extension agents no longer have the time or resources to visit farms personally, and many agents make most of their contacts with farmers by telephone or through meetings where as many as several hundred farmers can receive information at a time (47). In the area of agrichemical management, CESs provide recommendations on fertilizer and pesticide selection, application rates, and handling practices. Common CES information dissemination formats include newsletters, technical bulletins, computer databases, and field days. However, CES contacts with farmers on agrichemical management have often been superseded by farmers' more frequent contacts with agrichemical dealers, whom farmers typically see immediately prior to making agrichemical purchases (175,70). Some CESs (e.g., Illinois) have established training programs for dealers, through whom CESs can indirectly reach more farmers on agrichemical management. Other CES activities related to agrichemicals and groundwater quality include soil testing services, water quality education programs, and pesticide applicator certification training funded through FIFRA.

Farmers interested in low-input or nonchemical practices have noted that CESs lack information and expertise on management practices based on crop rotations and reduced agrichemical use (140). Some CESs, however, are developing their capacities to provide assistance on low-input and nonchemical farming practices, particularly as components of Low-Input/Sustainable Agriculture (LISA) research and education projects (81). LISA projects are playing key roles in expanding research and information bases on use-reduction and nonchemical approaches to reducing groundwater contamination. Another information source for farmers, when assistance is not forthcoming from local extension sources, is the ATTRA hotline, which draws on CES resources nationwide and acts as a national clearinghouse for alternative agriculture information (see box 5-G).

State Departments of Agriculture

State Departments of Agriculture (DOAs) play important 'gate-keeping' roles in managing agrichemical use within their borders. State DOAs with EPA-approved pesticide programs can expand or restrict the State's range of pesticide uses by granting experimental or conditional permits for nonregistered pesticides and instituting restrictions that are more stringent than Federal regulations.

The State Department of Agriculture is the lead agency for administering pesticide applicator certification programs in all but 16 of the 57 States and U.S. territories (167). In order for a State to administer its own certification program, the State's program plan must meet minimum Federal requirements and be approved by Federal and regional EPA offices (38). EPA administers the certification program if the State's plan is not approved. EPA currently administers programs in only two States: Colorado and Nebraska.

Some departments may also administer programs that help farmers try new agricultural practices. The Minnesota Department of Agriculture, for example, offers a "Sustainable Agriculture Loan Program" for farmers to borrow up to $15,000 at 6-percent interest for purchases or installations providing environmental benefits. Minnesota's DOA also has established a "Sustainable Agriculture Demonstration Grants Program,' which provided $284,000 in funding in 1989 (up to $25,000 per recipient) to encourage farmers to demonstrate alternative practices (87).

State Conservation Agencies

State conservation agencies are distinct from State-level SCS offices. They may be organized as State government departments, departmental divisions, committees, boards, or commissions. State conservation agencies administer State conservation laws, regulations, and programs; oversee Federal soil and water conservation activities; and provide technical assistance and training related to conservation. Cooperative relationships include State water quality agencies, State Departments of Agriculture, EPA regional offices, and State-level SCS offices.

State Water Agencies

Many States have designated a water resources agency or board to coordinate groundwater protection activities. In some States these agencies are active in providing assistance to local communities to protect groundwater resources. The Massachusetts Water Resources Authority, for example, initiated a project in 1989 to assist 14 communities to collect data on water supplies and possible contamination sources, identify recharge and watershed areas, prioritize water supplies at greater risk, and develop resource protection plans for each

Box 5-G—ATTRA: National Information Source on Agrichemical Use Reduction and Alternative Practices

ATTRA (Appropriate Technology Transfer for Rural Areas) is a national information hotline service that collects and disseminates information on agricultural technologies and cropping systems that reduce agrichemical use while maintaining crop yields. ATTRA specialists gather information nationwide from a variety of sources: electronic databases, university researchers, extension specialists, the USDA National Agricultural Library, and networks of technical experts and practitioners. Any person can request free information from ATTRA in writing or by calling its toll-free hotline, although ATTRA asks that requesters first try to obtain needed information from their local extension services. ATTRA specialists respond to requests by sending informational materials; providing referrals to experts and practitioners; and discussing alternative technologies, practices, or crops that might be considered by the requester.

ATTRA provides two main categories of information: 1) farm practices that reduce off-site environmental impacts of agrichemical from leaching, drift, and runoff; and 2) production systems characterized by greater crop diversity, which can reduce the need for agrichemicals, particularly insecticides. Information requests from ATTRA are increasing by 50 to 60 percent each year. ATTRA responded to 2,600 and 4,100 requests in 1988 and 1989 respectively, and 3,300 in the first half of FY 1990 (79). Increased requests appear to reflect rising interest among farmers in technologies that reduce agrichemical and production costs. Thus, ATTRA appears to provide an easy, accessible centralized information source for farmers and consultants on reduced-input and alternative (biological and cultural) agricultural practices.

The ATTRA hotline was established in Memphis, Tennessee, in 1987 but was moved in 1989 to the University of Arkansas campus in Fayetteville, Arkansas. Congress appropriated $500,000 and $750,000, respectively, for ATTRA for FY 1987 and 1988 through USDA-Extension Service funding, but appropriated $900,000 in funding for FY 1989 through the U.S. Department of the Interior's Fish and Wildlife Service, Office of Information (79). Prospects for continued funding, however, are uncertain. The high level of public concern about agrichemical contamination of surface and groundwaters, which is not likely to subside in upcoming years, may provide Congress with a strong rationale for appropriating sufficient funding for ATTRA to meet increased demands for information.

ATTRA's address is P.O. Box 3657, Fayetteville, AR 72702. The hotline number is 1-800-346-9140.

community. The project employs a computer-based geographic information system to combine databases and identify critical areas (49).

A variety of other State departments and agencies (e.g., State Department of Health, State Geological Survey) administer or cooperate in research, monitoring, and other programs to provide information and assistance to farmers on groundwater. Georgia's Department of Agriculture, for example, received EPA funding to evaluate pesticide impacts on groundwater and is working with the State's Department of Natural Resources to conduct well sampling and testing (50). The Washington State Department of Ecology samples well water for agrichemicals to obtain information on which conditions lead to groundwater contamination (49).

Soil Conservation Districts

Conservation districts are special-purpose units of government, organized under State law, that plan and coordinate local soil and water conservation efforts (159,94). Local citizens establish conservation districts by electing boards or commissions that sign Memoranda of Understanding with the Secretary of Agriculture and SCS. SCS then assigns conservationists to the districts, which may hire support staff to help provide services to farmers and other landowners. Conservation districts are governed by their elected boards, and they are commonly organized as State government subdivisions that follow county boundaries. In some States (e.g., Nebraska, Georgia, and California), conservation districts follow watershed boundaries.[9] The approximately 3,000 conservation districts in the United States cover about 98 percent of non-Federal land. Conservation districts form private, nonprofit associations at the State level to coordinate activities, exchange information, and participate as members in the National Association of Conservation Districts.

[9]Exceptions are Wisconsin, where conservation districts are units of county government; and New Hampshire and Alaska, where the entire State is a SOS conservation district divided into subdistricts.

Conservation districts are important interfaces between Federal policy directives and local implementation efforts in agricultural conservation programs. Although SCS conservationists assigned to the districts must respond to Federal agricultural legislation and regulations, the extent and kinds of assistance that conservation districts offer to farmers will also depend on staffing levels, available funding, and local resource management priorities. Conservation districts ''review and approve, or concur with plans developed by SCS," and their governing bodies "establish general priorities for addressing identified resource concerns' jointly with SCS (160). Thus, the agricultural conservation programs and practices supported through conservation districts are heavily influenced by State and local priorities and landowner needs.

Since 1985, for example, conservation districts have had to devote a major share of their workload to helping farmers meet FSA requirements (e.g., Conservation Reserve Program; conservation compliance for highly erodible lands). A national survey of conservation districts conducted in 1990 indicates that FSA assistance currently supersedes all other program priorities (table 5-14) and that conservation districts have inadequate levels of personnel to meet needs in all program areas, particularly in water quality (93). Insufficient staffing and finding will make it difficult for conservation districts to help implement additional cross-compliance provisions related to groundwater quality (e.g., agrichemical management plans).

Table 5-14-Types of Programs Conducted by Conservation Districts and Their Priority Rankings in 1990a

Program category	Mean priority ranking[b]
Food Security Act (conservation compliance, sod/swampbuster, conservation reserve)	4.09
Cropland erosion control	4.04
Water quality (nonpoint-source control)	3.91
Administrative support	3.69
Conservation education	3.64
Water quantity (irrigation, flood control, drainage)	3.35
Grazing land management	3.13
Urban erosion and sediment control	3.02
Municipal assistance (landfills, recycling, sludge disposal, etc.)	2.82
Forest management	2.66
Stormwater management	2.60
Mined land reclamation	2.40

[a]Survey conducted in December 1989. Survey results are based on *responses from 1,982* conservation districts, or 67 percent of the total number of conservation districts nationality.
[b]Mean priority ranting scale: 1 = low priority to 5- high priority.
SOURCE: National Association of Conservation Districts, *America's Conservation Districts Workload Analysis Survey* (Washington, DC: March 1990), p. 1.

County Governments and Local Committees

County governments (or other local governmental entities) also play a role in providing technical assistance to farmers through county extension funding. The proportion of county extension funding, however, varies greatly from State to State and within States (48). In some States, counties provide no funding at all, while in other States, counties may provide as much as 60 percent of the funding needed to support a local extension agent.

A variety of local boards, committees, or commissions also help set priorities for extension and agricultural conservation programs. Local boards may have a high degree of influence on the assistance programs available to farmers and on the kinds of conservation practices that are supported technically and financially. Wide variation in the types of local groups and their relative influence on priority setting explains a large portion of the difficulty in implementing national priorities in resource conservation.

Private-Sector Assistance: Commercial Agricultural Services

Reducing groundwater contamination by agrichemicals will require more information for and management by farmers. Since many farmers may not have time or expertise to devote to additional information-gathering or management, one strategy is for farmers to purchase advisory or management services that minimize environmental contamination or help reduce agrichemical use. Commercial services to improve nutrient and pest management could be provided by: 1) service departments of agrichemical dealerships and agrichemical-supply cooperatives; 2) advisory service firms and cooperatives which do not sell agrichemicals; and 3) independent consultants and field scouts.

Dealerships and Cooperatives

Agrichemical dealerships and supply cooperatives have helped disseminate innovations that can reduce groundwater contamination potential. These include rope-wick application of herbicides onto weeds; agrichemical banding rather than broadcast application; and use of returnable pesticide containers or recyclable container systems. Many regional

farm-supply cooperatives have developed advisory service packages that generate agrichemical recommendations based on individually tailored management plans or computer programs that adjust for soil tests and field characteristics (73). For example, Cenex-Land O'Lakes offers a crop management assistance program called AgriSource, which provides information on fertilizer application rates and pesticide compliance needs (21). Agway, Inc., a cooperative with over 100,000 members in the Northeast, offers an integrated crop management program incorporating Integrated Pest Management (IPM) strategies (171).

However, many cooperative advisory services, some of which are free-of-charge, serve as marketing techniques to encourage product sales. These services thus may conflict with goals to reduce agrichemical use as a way of protecting groundwater. Furthermore, the capacity of dealerships and farm-supply cooperatives to provide services that support alternative practices is not as well developed. Several features of agrichemical sales firms inhibit provision of information, advice, or innovations designed to reduce potential for groundwater contamination.

First, it is not in the interest of an agrichemical supplier to provide advisory services that ***reduce*** agrichemical use. Employees may not readily supply information to farmers about ways to reduce agrichemical use, because they are understandably reluctant to decrease sales (181,139). Recognizing this, some farmers obtain agrichemical recommendations only from firms that do not sell agrichemicals, since these firms do not have an interest in the amounts of agrichemicals sold (83). Care in selecting a reliable source of agrichemical recommendations is warranted; studies conducted by the University of Nebraska (106) and other land-grant universities indicate that fertilizer recommendations from some commercial testing labs were as much as two to three times higher than recommendations from university labs for identical soil samples (43). Since commercial labs in many cases are retained by dealers who have an economic stake in higher recommendations, farmers wanting to reduce environmental contamination by agrichemicals are likely to evaluate information sources carefully for potential conflicts of interest.

Second, employees of dealerships and cooperatives may simply not have the skills or expertise to offer advisory services that can help farmers reduce agrichemical use. Agrichemical supply f-need to develop and test services that replace product sales, because they face the risk of losing customers if they advise farmers incorrectly. Thus, agrichemical service firms are likely to require evidence that new services will keep their customers coming back and that service provision will be profitable. Some State CESs and professional trade associations offer training programs specifically designed for agrichemical dealers and their employees (70). Nebraska's Fertilizer & Agchem Association, for example, has established a Certified Crop Production Advisor Program to train and certify crop advisors (114).

Third, provision of advisory services by commercial agrichemical suppliers is constrained by current industry trends (175,56). These include a decline in the number of dealerships, liability concerns, and increased regulatory requirements which add to the cost of doing business (e.g., sales reporting, recordkeeping, construction standards, accident plans, spill reporting, secondary containment, and disposal). These factors are causing some dealers to go out of business and are making it difficult for agrichemical suppliers to offer new services, hire new employees with environmental expertise, or improve current employees' technical and communications skills.

In light of the above constraints, programs to enhance agrichemical dealers' and cooperatives' capacity to provide advisory services are likely to require economic, fiscal, or professional incentives. These include government-sponsored training programs, subsidies for employee training, and 'dealership accreditation" for firms that participate in training programs or offer specified services. Licensing requirements for agrichemical sales outlets could also specify training and services provision. The incentive to provide cost-saving advisory services may be greater for cooperatives than dealerships, however, because cooperatives are owned by their customers who ultimately benefit. Although advisory services would seem to be an attractive option for cooperatives, this strategy would require coordination and communication among cooperative members, directors, and managers. Regardless of the type of agrichemical sales firm, however, farmers are the ones who will ultimately pay for services and their development costs.

Independent Advisory Firms and Consultants

Advisory firms and independent crop consultants who do not sell agrichemicals can offer services without conflicts of interest associated with sales volumes. These firms and consultants are playing an increasingly important role in providing technical assistance to farmers, and groundwater protection concerns are likely to generate further demand for these services. Increasing the demand and availability of crop advisory services is one of the goals of the ASCS pilot program offering cost-share for "Integrated Crop Management" services in the 1990 to 1992 crop years. The ASCS program confers cost-share payment eligibility only on consultants not associated with agrichemical sales firms (151).

Development of advisory services will require adequate availability of persons who are trained and skilled in delivering needed services. Currently, professional organizations and trade associations are the best sources of information on agricultural firms and consultants offering environmental advisory services. In 1988, the number of agricultural consultants who were independent or employed by other firms was estimated at about 13,200 (table 5-15). The American Registry of Certified Professional Agricultural Consultants (ARCPACs), a certification program co-sponsored by the American Society of Agronomy, the Soil Science Society of America, and the Weed Science Society of America, also provides regional estimates of the numbers of trained agricultural professionals (4,125). Some States (e.g., Indiana) have established certification programs for agricultural consultants based on ARCPACs criteria. State licensing or certification programs for consultants can facilitate farmers' access to reliable services by trained advisors.

The public sector could assist the private sector in design, development, and delivery of advisory services in the following ways: 1) providing agronomic and economic information on feasibility of modified or reduced agrichemical applications; 2) training programs for employees; 3) education and licensing programs for advisors (e.g., IPM consultants, field scouts, crop advisors); and 4) education programs on innovative service delivery to replace products with services. Programs to enhance commercial fins' capacity to provide information and services on reduced-chemical use or nonchemical practices will expand farmers' management options overall.

Table 5-15-Numbers of Agricultural Consultants, National Estimates, 1989

Type of consultant	Estimated numbers
Independent	8,584
Employed by other firms (dealerships, cooperatives, agrichemical manufacturers)	4,664
Farm managers employed by banks, real estate firms, etc.	4,863
Farm managers employed by government agencies	5,463
Farm managers employed by large-sale farms or food processing firms	693
Others in allied fields (business or academia)	572
Total	24,839

SOURCE: *Ag. Consultant* (Willoughby, OH: Meister Publishing, June 1989).

Farmer Initiatives

Producer organizations and other farm membership groups have undertaken initiatives to test well-water, facilitate farmstead assessments, and educate members about groundwater vulnerability. The American Farm Bureau Federation, for example, has developed a "Self-Help Checklist for Farmsteads and Farm Fields" to help producers assess their farming operation's potential to affect groundwater supplies (3). Technical assistance programs can draw on producer initiatives as startup points for encouraging producers and other landowners to protect groundwater from contamination.

Information exchange among farmers is an important mechanism for disseminating information on farm practices. Farmer-to-farmer exchange complements information from formal sources in the public and private sectors and addresses constraints sometimes associated with these sources (e.g., conflicting information from different organizations, scarcity of information on alternative practices). Farmer-to-farmer information exchange may take on new and even greater importance in facilitating adoption of groundwater protection practices as a source of information relevant to local conditions and producers' experiences. Mechanisms for farmer-to-farmer information exchange include farmer-to-farmer referral networks (103), crop management associations (19), and soil and water conservation groups. These can provide farmers with peer and community support and help them determine which groundwater protection practices are feasible and profitable.

Farmer-to-Farmer Networks

Many farmers experimenting with reduced-chemical-input, biological pest control, or other nonchemical. farming practices have perceived that the agricultural research and extension community has been uninterested in or uninformed about such practices (140). Furthermore, alternative farming practices tend to require a greater understanding of farming systems interactions and longer adoption periods during which producers can test and adapt them gradually. As a result, farmers interested in alternative approaches have largely sought information and advice from each other, forming what are referred to as ''farmer-to-farmer networks" (103).

Some of these networks are highly informal, while some have incorporated as nonprofit membership organizations to provide information and assistance to other farmers. In some cases, nonprofit organizations have facilitated the development of farmer networks. Private nonprofit organizations associated with farmer-to-farmer networks vary widely in composition and structure, and many employ full-time help to provide technical support. Some organizations are composed entirely of farmer-members, such as Practical Farmers of Iowa, while other organizations, such as the Land Stewardship Project in Minnesota, have broader memberships that include nonfarmers interested in supporting land stewardship efforts.

Farmer-to-farmer networks have up to three functions: 1) on-farm experimentation, 2) information-gathering through contacts with external sources of assistance, and 3) information dissemination through educational programs or field demonstrations. All organizations provide some type of information and technical assistance on alternative practices, and these may range from improved agrichemical management techniques to reduced-chemical-input methods to organic cropping systems. OTA estimates that at least 100 such organizations existed in the United States in 1988. In October 1988, OTA sent survey questionnaires to 40 of these organizations representing a wide geographic range and received 29 responses (table 5-16) (140).

Most of the organizations that responded to the survey are involved in investigating and sharing information on alternatives to agrichemical inputs (box 5-H). Surveyed organizations reported conducting education, demonstration, and information-sharing, either through interested volunteers or paid

Photo credit: Office of Technology Assessment

Field days sponsored by educational organizations and farmer-to-farmer networks serve to disseminate information on improved agrichemical management and reduced-chemical and alternative farming practices. Here, test plots are viewed at the Chesapeake Bay Foundation's Claggett Farm.

staff. Organizational activities are funded either by member donations, foundation grants, or contributions from other sources such as churches or endowments. Most organizations are small, with five or fewer full-time staff and median budgets in the $100,000 to $150,000 range. Half of the organizations operate at the State or sub-State level. The median number of farmers providing information per organization is 50 to 100, with 300 to 400 farmers receiving information. Twenty-five of the twenty-nine respondents worked with State land-grant university researchers in 1987-88, and 20 had cooperative projects with CESs that year. The organizations' most frequently cited information dissemination methods were farmer meetings, workshops, and field demonstrations.

Farmer-to-farmer networks and their associated support organizations are emerging as important local sources of information on reduced-agrichemical practices and nonchemical practices and production systems (103). Two-thirds of the groups responding to the survey had been established after 1976, with the three newest ones starting in 1987. Recent increases in numbers of these groups appear to indicate a growing interest among farmers in

Table 5-16-OTA Survey Respondents: Private[a] Nonprofit Organizations Associated With Farmer-to-Farmer Networks

Name	Location
Alternative Energy Resources Organization (AERO)	Helena, MT
California Certified Organic Farmers	Santa Cruz, CA
California Clean Growers Association	Dinuba, CA
California Institute for Rural Studies	Bakersfield, CA
Center for Holistic Resource Management, Inc.	Albuquerque, NM
Claggett Farm, Chesapeake Bay Foundation	Upper Marlboro, MD
Committee for Sustainable Agriculture	Colfax, CA
High Desert Research Farm	Abiquiu, NM
Iowa Natural Heritage Foundation	Des Moines, IA
Kansas Rural Center	Whiting, KS
The Kerr Center for Sustainable Agriculture, Inc.	Poteau, OK
Land Stewardship Project	Marine, MN
Maine Organic Farmers	Augusta ,ME
Meadowcreek Project	Fox, AR
Michael Fields Agricultural Institute	East Troy, WI
Nebraska Sustainable Agriculture Society	Hartington, NE
New Alchemy Institute	East Falmouth, MA
Northern Plains Sustainable Agriculture Society	Windsor, ND
Ohio Ecological Food and Farm Association	Plymouth, OH
Oregon Tilth, Inc.	Tualatin, OR
Practical Farmers of Iowa	Boone, 1A
Rodale Institute-Wisconsin	Lodi, WI
Rodale Insitute-Arkansas	Fox, AR
Sunny Valley Foundation	New Milford, CT
Virginia Association of Biological Farmers	Flint Hill, VA
Winrock International, Inc.[b]	Morrilton, AR
Wisconsin Rural Development Center	Black Earth, WI

[a]Survey questionnaires also were sent to two Resource Conservation and Development Districts (RC&Ds) for information on exam pies of RC&D activities. RC&Ds are publicly funded organizations associated with local soil and water conservation districts, and they promote a wide variety of projects, including include resource planning and technical assistance for farmers and ranchers to reduce soil erosion and protect water resources. West Stanislaus RC&D in Patterson, CA, conducts irrigation seminars but notes a lack of locally applicable practices to address acute groundwater problems in its area. Seneca Trail RC&D in Franklinville, NY, is not directly involved in practices for reducing groundwater contamination but provide assistance on rotational grazing and no-till seeding which reduce erosion and runoff. RC&Ds provide potential structures for assisting farmers in implementing practices to improve groundwater quality.

[b]Winrock International institute for Agricultural Development, Inc. does not directly work with farmer-to-farmer networks but is lead organization for a farmer extension/research project and farming systems database involving 18 organizations.

SOURCE: Office of Technology Assessment, 1990.

alternative practices. Because farmers in local networks have had more experience in developing farming systems that aim to reduce agrichemical use, they offer important sources of assistance on use-reduction and nonchemical approaches to groundwater protection. Farmer-to-farmer networks also offer research and extension opportunities for documenting production practices to reduce groundwater contamination that are specific for local climatic, topographic, and hydrogeologic conditions. Closer examination of these farmers' production records and methods will be required in order to evaluate the profitability, production potential, and water-quality impacts of these systems.

Some land-grant universities have established formal working relationships with farmer-to-farmer networks (55). These universities are seeking technical observations and information from farmers on biological and cultural practices, a process that might be considered ''reverse technology transfer. A key advantage to working with farmer-to-farmer networks is their ability to provide locally relevant, area-specific information on management practices that can serve to offset agrichemical use. A possible drawback, however, is that farmers associated with many networks are not viewed as "typical,' because their primary strategy for maintaining economic viability is to reduce costs rather than expand their operations (140). Nevertheless, land-grant university collaboration with farmer networks is one way for universities to respond to criticisms that the traditional agricultural research and extension system has overly emphasized research that favors large-farm, capital-intensive agriculture.

Box 5-H—Alternative Farming Practices: Examples Cited by Farmer-to-Farmer Networks in OTA Survey (categories in order of decreasing frequency)

Animal Manure Management—Uses of animal manure as substitute for commercial nitrogen fertilizers; collection and storage of animal wastes; control of run-off from storage sites or fields; comporting; application timing and method.

Cropping Practices-Optimal sequences for crop rotations; identification of crop rotations and component crops best suited to region; cover cropping; uses of legumes or green manures as substitutes for commercial nitrogen fertilizers; intercropping of legumes and grains to test crop complementarily; use of legumes for improved nutrition for livestock hay and pasture.

Tillage Practices—Experimentation with various types of tillage equipment, e.g., harrows, rod weeds, undercutter; rotary hoes; effectiveness of tillage methods; combinations of tillage and reduced herbicide applications as weed control system.

Comporting and Mulching Methods—Use of mulches to prevent water loss; use of mulches to add nutrients to soil and discourage weed growth; comporting as a method of reducing waste runoff and leaching to groundwater comporting as a method for building soil organic matter.

Soil ***Testing-soil*** testing for nitrogen to reduce the amount of purchased nitrogen fertilizer; identification of most effective times and methods for applying animal wastes; effectiveness of cover crops and crop rotations in building soil nitrogen.

Economic Comparisons—Economic comparisons of herbicide-based weed control systems v. tillage-based weed control; general economic comparisons between experimental and current practices.

Pasture Utilization and Management-Grazing management methods, including rotational grazing; increased pasture diversity and legume use; multiple species grazing.

Biological Insect and Nematode Controls-Use of diatomaceous earth for internal and external livestock parasites; use of pheromones to control oriental fruit moth; effect of increased soil organic matter on nematode control.

Biological Weed Controls-Use of rye (which has allelopathic properties) as a cover crop to control weeds; use of walnut leaves to control weeds; rotational sheep grazing as weed control method.

SOURCE: Responses to OTA ''Survey of Private, Nonprofit Organizations' Activities in Research, Education, and Public Policy on Farming Practices That Can Reduce Groundwater Contamination.'' November 1988, summarized in OTA contractor report by Turck and Kroese, 1989.

Therefore, land-grant university support of peer-based information exchange within farmer-to-farmer networks can complement CES's more centralized mode of information and assistance delivery. In the next decade, universities collaborating with farmer networks are likely to be the institutions most readily able to supply farmers with information and recommendations that fall under the use-reduction and nonchemical approaches to reducing groundwater contamination.

Crop Management Associations

Crop Management Associations (CMAs) are local, farmer-run, nonprofit organizations in Pennsylvania, in which farmer-members pool resources to hire their own full-time technical help (19). Many farmers in Pennsylvania are dairy farmers, with average farm size of 150 to 200 acres, and they often apply ''insurance' treatments of agrichemicals because they lack the time to monitor field conditions closely (119). The first CMA began in 1979 when farmers requested organizational help from their county extension agent. The Pennsylvania State CES currently coordinates a statewide CMA program, in which members pay annual membership dues plus per-acre fees to employ their own field scouts or ''consultants. '

The current CMA program has 13 CMAs, employing 15 full-time consultants with undergraduate interns providing summer help. CMA consultants, who typically hold bachelor's degrees in agronomy or related areas, gather and record crop production data, scout insect populations, monitor crop diseases and nutrient deficiencies, and help keep production cost records. CMA members have documented up to 75 percent savings in production costs for chemicals,

labor, and equipment resulting from weekly field insect scouting (75).

Since the beginning of the CMA program, some CMAs have stopped functioning while others have been highly successful. The main problem with the CMA program is difficulty in recruiting and retaining good consultants, because the key to CMA success is a competent consultant who has the trust and confidence of its members. Members who are not satisfied with their consultant's performance tend to drop out of CMAs. Since CMA consultant jobs provide excellent learning experiences, many consultants leave after 1 or 2 years after being offered better-paying jobs with agrichemical companies or independent consultant fins.

The Pennsylvania CES is trying to find solutions to the problem of employee retainment by advising CMAs on how to provide better salaries that will keep talented people working for them. CMA members are currently paying about $3 to $4/acre for consultant services, which provides annual salaries of only $14,000/year. Pennsylvania's CES estimates that the minimum payment needed to retain a consultant at an annual salary of $20,000 would be $7/acre. Since the average CMA involves 25 farms and 4,000 acres, $7/acre fees and annual membership dues of $100/farm would generate $30,000 to cover a consultant's salary and operating expenses.

Only an estimated 1 to 2 percent of Pennsylvania's farmers participate in CMAs, presumably due to the difficulty in convincing farmers that consultant services are worth their cost (1 19). Consequently, the Pennsylvania CES is developing a farm recordkeeping system for personal computers, which could make recordkeeping faster and easier; next year CES plans to assist 100 farmers in their recordkeeping in order to document agrichemical and other expenditures and the costs and savings from consultant services. Thus, if staffing problems can be resolved and adequate documentation of cost-savings provided, CMAs could be an effective mechanism for CES to extend its resources and provide technical assistance to larger numbers of farmers.

Financial Assistance for Water Quality Protection

Cost-share and other financial incentive programs can encourage farmers and ranchers to implement groundwater protection practices. Possible vehicles for such financial assistance include Federal, State, and local government programs. However, States have primary responsibility for most environmental programs, and policymakers must recognize that State financial assistance to landowners for groundwater protection will have to compete with a growing number of other environmental program being implemented by the States. The ***1989*** National Governor's Association (NGA) report emphasizes that States' environmental program costs are quickly outstripping government revenues (95). By the year 2000, annual Federal, State, and local costs for all environmental programs are projected to reach $60 billion, up from $31 billion in 1977 (134).

State environmental protection programs can receive funding from three principal sources: 1) Federal grants designated for environmental operating budgets, construction, or capital improvements (including Federal cost-share programs); 2) State general revenues, which come from income, sales, and property taxes; and 3) State sources other than general revenues, sometimes called "Alternative Financing Mechanisms" (AFMs), which include user fees, permit fees, pollution discharge fees, environmental taxes, bonds, revolving loan funds, and compliance penalties. AFMs have become common sources of capital and revenue for specific environmental activities.

State funding allocated to county or watershed programs may also be supplemented with revenues from county or municipal governments or special units of government, such as Soil and Water Conservation Districts. Potential sources of State funding (general revenue funds and AFMs) have been administered in three ways:

- State cost-share funds administered through State agricultural or conservation agencies and local Conservation Districts,
- low-interest loan programs, and
- property tax breaks.

Appendix 5-1 demonstrates the variety of cost-share and financial incentive programs by which States have already attempted to address a range of resource management problems in agriculture. Some mechanisms allocate general revenue funds for high-priority resource areas, while others establish new income sources (AFMs).

Federal contributions to States' environmental programs have declined in the last 10 years. Overall,

EPA grants to States for environmental operations budgets dropped 42 percent (from ***$499*** million to $288 million, based on 1988 dollars), between 1979 and 1988. Water quality funding fell by 50 percent during the same period from $217 million to $108 million (134). Thus, even as States increased their environmental programs, they received less from the Federal Government.

Funding new environmental programs also has been difficult because many States' general revenues have remained at previous levels or declined. The NGA reported that 44 States have implemented a total of 431 different AFM programs, which generate $3.2 billion for States' environmental budgets. The NGA report noted that AFMs currently support 11 to 20 percent of State environmental budgets but that this proportion is not likely to become larger (95). New monies received from AFMs, however, have often replaced general revenues that were shifted to nonenvironmental programs, resulting in little net gain in environmental program support. Many State officials believe that future environmental protection demands will have to be met through increases in general revenues. Thus, if Federal funding trends continue, and State and local governments shoulder primary financial responsibility, the public must recognize that increases in sales, property, or income taxes are likely to be needed for implementation of new environmental programs.

Public-Sector Coordination To Enhance Technical Assistance

States can improve mechanisms to expedite research, coordinate agency actions, and disseminate information on agricultural management to protect groundwater resources. Problem areas can be identified, and agricultural practices appropriate for local soil, water, and other resource conditions in the State can be developed and promoted.

Various multi-State, State, and sub-State management programs have been established to address single or multiple resource concerns. However, most current programs, which focus on one or a few resources, have arisen from separate legislative origins and are administered by different agencies or divisions. Producers or landowners who seek assistance on comprehensive resource management face difficulties in bridging the separate "turfs" created by different agencies and their programs. Some landowners may not pursue efforts to improve resource management because they hear conflicting messages from public agencies. Thus, many current programs are not designed or managed to provide landowners with information on dealing with the whole range of resource concerns. One exception is Iowa's Integrated Farm Management Demonstration program, which provides "packages" of information and assistance to farmers on soil, water, and other crop management practices (see box 5-I).

Agricultural decisionmakers today may be concerned not only about groundwater contamination, but also about groundwater depletion, surface water pollution, soil erosion, sediment deposition, wetlands protection, and loss of wildlife habitat. With Shrinking revenues and growing environmental costs, creation of a separate groundwater protection program may be less cost-effective and more duplicative than a program which builds on existing resource programs. Just as producers need to consider all relevant resource concerns in making farm or ranch management decisions, State and local governments need to develop mechanisms to review, prioritize, and coordinate their efforts in delivering resource management assistance.

In addition, individual or scattered efforts by self-motivated producers to seek information and implement improved management practices may not be sufficient to achieve desired reductions in groundwater contamination over broad regions. If States and local communities are to achieve groundwater protection across broad areas overlying critical aquifers, strong public support for protection efforts needs to be communicated to all landowners involved. Landowners will be much more motivated to consider off-site impacts and groundwater quality if they are made aware of the surrounding community's interest in improved resource management (75). Thus, landowners' voluntary actions may depend on hearing coordinated messages from the public as well as from government agencies.

Some mechanisms already exist to effect broad-based coordination and public participation that can influence individual decisionmaking on resource management. These include decisionmaking through Soil and Water Conservation Districts, Resource Conservation and Development Districts, and State Water Quality Management Boards. Other procedures such as Coordinated Resource Management Planning could be assessed for their potential

Box 5-I—Iowa's Integrated Farm Management Demonstration Projects

As the Nation's highest ranking State in agrichemical use, Iowa has taken a leadership role in implementing demonstration projects to encourage voluntary improvements in agnchemical management. Projects are designed to improve nutrient, pesticide, crop, soil, and water management on Iowa farms and promote the integration of agrichemical management techniques with tillage and cropping practices. Demonstration projects thus aim to address several resource degradation problems at once, including groundwater and surface water contamination from agrichemicals, soil erosion, and Iowa's high consumption of nonrenewable fuels (used in the manufacture of fertilizers and pesticides).

All projects demonstrate combined "Best Management Practices" (BMPs) or integrated management techniques, such as evaluating nitrogen placement or herbicide banding with ridge tillage (65). However, different projects may emphasize certain practices depending on local resource concerns, production systems, and participant organizations. Many demonstrations involve water chemistry monitoring; testing of soils, manures, and plant tissues; pest scouting and crop monitoring; measurements of energy consumption; and pesticide sprayer calibration. In some cases, farmers also are assisted with crop enterprise recordkeeping, crop, livestock and land management inventories, and cost-share for consultant services (64).

Demonstration projects have been funded with oil overcharge monies from the Iowa's Agricultural Energy Management Fund, agrichemical taxes and fees authorized by the Iowa Groundwater Protection Act of 1987, and State general revenues. Project implementation has involved broad-based cooperation and coordination among: 1) State agencies, including the Iowa Department of Agriculture and Land Stewardship (DALS) and Iowa Department of Natural Resources (DNR); 2) Iowa's three public universities, including Iowa State University's Cooperative Extension Service (CES) and State Agricultural Experiment Station (SAES); 3) nonprofit farm and conservation groups, such as the Iowa Natural Heritage Foundation and Practical Farmers of Iowa; and 4) USDA's Agricultural Research Service and Soil Conservation Service. Iowa's farm management education and demonstration efforts include five major projects.

Integrated Farm Management Demonstration Project—The Integrated Farm Management (EM) Demonstration Project is a statewide, 5-year project begun in 1987. Iowa's CES and SAES have set up demonstration sites at more than 300 locations, some in each of Iowa's 99 counties. Although some demonstration sites are located at university research centers, the majority of demonstration sites are in farmers' fields. Extension staff design, set up, and provide most of the labor and management required by the experimental plots, with farmers providing land, supplies, and some labor. However, some projects are wholly operated by farmers. Each demonstration shows replicated plots of several different management treatments for comparison, including a treatment using farmers' current practices (64). The project, authorized to continue through the 1991 crop year, also has survey and evaluation components to monitor local farmers' receptivity to educational programs and effectiveness of project efforts in changing farm practices to protect groundwater (110,30).

Butler County Integrated Crop Management Cost-Share Project—The Butler County Integrated Crop Management (ICM) project is a 3-year pilot program which provides cost-share assistance to 50 farmer-cooperators for implementing agrichemical-related BMPs. The purpose of the project is to assess how crop advisory services can improve farmers' profitability and management practices. Because the costs of advisory services to farmers are being phased in gradually, the project also provides a test to see how services provision can be transferred to the private sector over the 3-year period. In the first year, farmers are provided with services free-charge by six field scouts trained by CES. The farmer-cooperators are expected to pay $1.50 and $3.00 per acre for scout services in the second and third years, respectively, and then take over full payment for scout services when the project is over. In 1989, the total cost of services was estimated at $4.50 per acre, with farmers saving about $20 per acre in agrichemical costs. That year the 50 cooperators reduced nitrogen applications by about 260,000 pounds and improved their net income overall by a total of $500,000. One farmer-cooperator reported avoiding a loss of $42,000 due to timely treatment of cutworms, while another saved $15,000 in additional fertilizer costs when soil tests showed that he did not have to add phosphorus and potassium (66).

Watershed-Based Projects—Farm demonstration projects in three Iowa watersheds have also been established to evaluate current farm practices, provide information on BMPs, and monitor BMP implementation. The frost and best known project, located in the Big Spring Basin of northeast Iowa, has provided a unique outdoor 'laboratory' to observe groundwater impacts of farming activities in karst areas, because Big Spring is a completely agricultural

Continued on next page

Box 5-I—Iowa's Integrated Farm Management Demonstration Projects-Continued

108-square-mile watershed draining into a single outflow (52). Virtually all 300 farmers in the Big Spring Basin, an intensive livestock and grain area, received information on groundwater impacts and recommended manure and fertilizer practices (69). About 40 percent of Big Spring Basin farmers had reduced their nitrogen applications after 2 years (108). In addition, Iowa CES established two other watershed projects, each with about ten cooperators, in Audubon and Clayton Counties to demonstrate BMPs. Cooperating farmers have documented nitrogen reductions of up to 20 percent of nitrogen and lower herbicide expenditures (67).

Model Farms Demonstration Project—Based on favorable results of previous farm demonstration projects, the Iowa Legislature in 1989 appropriated $600,000 per year over 3 years for five additional "model farm demonstration projects." The model farm demonstration projects will be designed to enhance farm profitability and reduce environmental impacts of row crop production. The model farm projects, patterned after the Big Spring and Butler County projects, will provide information and demonstrations of integrated farm management packages involving 15 to 50 farm demonstrators per project, with information "marketed" to residents in each multi-country area, reaching an estimated total of 2,050,000 people statewide over the course of the project (53). All projects will enlist the participation of local government, farm, and conservation groups. Three of the projects will involve a 3-year phase-in of crop advisory services described above, including expanded training of crop consultants, agrichemical dealers, and staff of farm supply cooperatives.

Additional Public Education Inititives-In addition to its integrated approach to resource protection on farms, Iowa is funding resource protection and education efforts to reach significant numbers of urban and rural nonfarm populations as well. The Resource Enhancement and Protection Act (REAP) of 1989 authorizes expenditures totaling $300 million over the next 10 years for environmental programs, using revenues from State corporate income taxes, the State lottery, and a State-sponsored credit card (57). REAP provides funding to county conservation boards and creates county and regional "Resources Enhancement Committees," composed of government, farm, conservation, and other local representatives, to develop 5-year plans for proposing and implementing resource enhancement projects. REAP also authorizes funds for purchase of public lands for permanent land retirement and resource protection and for permanent conservation plantings, all of which could have major groundwater quality impacts. Finally, REAP provides funds for water quality protection projects which integrate traditional soil conservation cost-share payments with agrichemical management initiatives.

Public education efforts like those provided for in REAP could help urban and rural residents recognize that they share responsibilities with farmers in protecting the State's natural resources. Such programs have potential to encourage adoption of improved farm management practices in three ways: 1) encouraging urban and rural residents to "clean up their own acts, " since farm residents are likely to resent being ''singled out' on resource protection efforts; 2) influencing nonfarm populations to financially support programs that help farmers implement resource-protecting practices; and 3) stimulating broad-based local participation in resource protection efforts and encouraging communication between nonfarm residents and farmers on local priorities and goals for resource protection.

to help producers integrate resource management concerns (5). Program coordination at the State level could be greatly improved and public input could be broadened to build and communicate support for integrated resource management in agriculture.

Several agencies have developed agrichemical management and water quality programs and educational materials that could be incorporated into more comprehensive farm resource management planning. These include CES fertilizer and pesticide recommendations, soil testing and field scouting programs, educational materials on water quality, and SCS information on water quality and Best Management Practices. Effective use of these materials and programs in agricultural resource management, however, depends on: 1) the validity and usefulness of available information; 2) the degree to which extension agents and conservationists understand and integrate the information into daily procedures; 3) extension agents' and conservationists' skills in conveying new information and techniques to landowners; and 4) their degree of commitment in using the materials and convincing landowners of the importance and trade-offs of incorporating water quality and other resource concerns into decisionmaking. CES and SCS efforts could be coordinated better with each other and with those of conservation districts and State government

agencies to ensure improved and consistent use and updating of water quality materials.

A 1989 National Governors' Association (NGA) report on State initiatives addressing agricultural impacts on water quality recognized regulatory approaches as often being ''impractical and ineffective' and emphasized the use of voluntary approaches in encouraging farmers to reduce adverse environmental impacts from their farm operations (95). In supporting voluntary approaches, the report cited five main strategies for States to consider in setting program priorities:

1. emphasizing education and technical assistance for farmers;
2. investing in research designed to address the biggest information gaps and to assist areas in greatest need;
3. initially placing highest priority on program efforts with lowest costs and greatest potential impacts;
4. building a comprehensive approach to resource protection, including surface water, groundwater, and soil erosion; and
5. including public education in State efforts.

These strategies will require coordination and commitment of a wide variety of State and local agencies, as well as input from State and regional offices of Federal agencies, in order to facilitate communication, promote implementation, and allow for adequate program monitoring and evaluation.

A public-sector framework of State and local agencies and local conservation districts already is in place to provide technical and financial assistance to farmers on reducing agrichemical contamination of groundwater. However, some problems and obstacles will need to be addressed to make the system more effective in delivering needed information and assistance, and specific changes relative to agrichemical management will need to be implemented. Whenever possible, public-sector assistance should support development of private-sector capacity to provide information and assistance.

RESEARCH, EXTENSION, AND EDUCATION TO ENHANCE DECISIOMAKING

In response to perceived public needs, the agricultural research and extension community has in the past given highest priority to increased production efficiency, providing a cheap, stable, and abundant food supply and increasing food for export. U.S. agriculture today, however, faces broader, long-term public demands to reduce environmental pollution and protect natural resources in agriculture. These latter objectives, however, often are of low priority for individual farmers confronted with short-term economic pressures. Farmers and the public will need to share responsibility for natural resource protection if U.S. agriculture is to move away from its emphasis on individual, production-oriented decisionmaking toward a greater integration of individual and societal objectives that also emphasize environmental quality.

Satisfying the broader demands placed on U.S. agriculture will require a wider range of research, extension, and implementation efforts that place higher priority on natural resource protection and environmental quality. Decisionmaking for groundwater protection represents only one aspect of the societal need to protect natural resources in agriculture. Thus, a comprehensive approach to natural resource protection in agriculture will not focus solely on groundwater protection-it will also address the need to maintain surface water quality, air quality, water quantity, land and energy supplies, soil productivity, plant and animal diversity, and the pool of human knowledge and skills needed to manage these resources. Programs to assist farmers in making management decisions to protect groundwater could fit into a broader research and extension strategy to enhance farmer decisionmaking to protect natural resources overall.

Enhanced Decisionmaking for Natural Resource Protection in Agriculture

Enhanced farmer decisionmaking for natural resource protection is characterized by:

1. an understanding of the farm's natural resource protection needs and appropriate priorities, which will depend on the type of farm and the farm's physical setting;
2. an understanding of the farm as a system of interrelated components and its relation to the surrounding environment; and
3. an ability to integrate resource protection and production objectives in short- and long-term planning and decisionmaking.

If a farm is located in a hydrogeologically vulnerable setting, or if agrichemical management

practices are associated with a high degree of contamination risk, the farmer's need to reduce groundwater contamination will be a higher priority than some other resource concerns. In different settings or production systems, other natural resource concerns may need to be of higher priority in management plans. Thus, programs to enhance farmer decisionmaking will not only have to be broad but also flexible and adaptable to the site-specific natural resource protection needs of each farm.

Enhanced farmer decisionmaking to protect natural resources on a comprehensive basis will require improved decisionmaking by researchers, policymakers, and technical assistance agencies. Broader, multi-objective responses from the research and extension community will be more complex and interdisciplinary than previous efforts emphasizing production (120). This broader approach will require greater attention to decisionmaking and increased coordination and linkages among research, extension, farmers, policymakers, and the public. Thus, multi-objective research and extension efforts will require increased use of the social sciences and greater support for interdisciplinary research and extension. The United States' capacity to support groundwater protection decisionmaking through its research, extension, and education systems will be framed by these systems' capacities to support natural resource protection decisionmaking in general.

Research and Extension Needs To Enhance Decisionmaking

The U.S. public agricultural research system is linked to an extensive information and assistance delivery system made up of State and Federal extension, conservation, and financial agencies (146,142,40,16,97). To date, agricultural research priorities- shaped by individual scientists' interests, Federal competitive grants programs, State legislative priorities, agricultural experiment station policies, scientific societies, and trade associations—have primarily emphasized technological research for obtaining "low cost, safe food, and efficient production" (82). As a result, technology-based priorities have also been emphasized in the agricultural information and assistance delivery system. Less attention has been paid to farmer constraints to adopting technologies (101) and to socioeconomic and environmental impacts that can result from technology adoption (1 15).

Need for Broader Research Input and Two-Way Information Exchange

Although the U.S. agricultural research and extension system was originally created to meet farmer needs, the main focus of the research and extension system has shifted since World War II toward development of science-based production technologies (115). Less emphasis has been placed on farmer needs and constraints, particularly as they relate to natural resource protection in agriculture. To a great extent, the prevailing agricultural technology transfer process can now be characterized as a "top-down" and centralized flow of information from researchers to extension specialists to progressive farmers having the management skills and capital resources to invest in new technologies (128,16). The prevailing model of agricultural technology transfer also embodies a widely accepted view that innovations will spread from progressive farmers to less innovative farmers (see box 5-J). The prevailing perspective on technology transfer has been useful in explaining farmer adoption of commercially successful technologies that increase productivity or net returns, but it has not been as applicable to understanding adoption of less profitable, "environmental" technologies that protect natural resources (113).

Similarly, the technology-based, top-down approach to agricultural research and extension has worked extremely well in promoting productivity increases, but it may not work as well in facilitating natural resource protection (103). In fact, the current agricultural research and extension system's record in promoting natural resource protection in U.S. agriculture is relatively poor—American farmers continue to lose 3 billion tons of topsoil every year, and many areas of the country have failed to achieve extensive implementation of farming practices that reduce soil erosion and water quality degradation (34,103). Since natural resource protection practices for agriculture (e.g., BMPs) typically have been developed and presented to farmers through "top-down" research and extension programs, inappropriate technology transfer approaches may be one reason why farmers have not extensively adopted natural resource protection practices throughout the United States (113).

Prevailing views on the agricultural technology transfer process appear to have shaped research and extension relationships with farmers over the last

Box 5-J—Agricultural Innovations and the Legacy of Diffusion Research

"Diffusion" in agriculture is the process by which innovations, or different ideas, are communicated and adopted among farmers over time (128). The most influential early article on diffusion of innovations was on adoption of hybrid corn in Iowa (130). Diffusion research on farmer adoption of hybrid corn and other commercially successful innovations has led to widely held perceptions among agricultural researchers about the ways innovations spread among farmers.

Hybrid corn was developed by researchers at Iowa State University and other hind-grant universities and released in Iowa in 1928, Farmers prior to that time grew their own open-pollinated corn and saved seed for planting the following year. Hybrid corn increased yields per acre by 20 percent but lost its yield-producing vigor if planted the next year. Farmers switching to hybrid corn thus had to purchase seed every year, which meant significant changes in management behavior. Agricultural extension agents and seed salespersons heavily promoted the innovation (128).

Ryan and Gross traced the adoption of hybrid corn among 259 Iowa farmers between 1928 and 1941. They found that the adoption rate formed an "S-shaped curve" over time. Only 10 percent of the farmers had adopted hybrid corn in the first 5 years, after which the number of adopters increased rapidly. About 40 percent of the farmers adopted hybrid corn by 1936, with the adoption curve soon leveling off as fewer and fewer non-adopters remained. Early adopters were described in positive terms as ''innovators' and were observed to have larger farms, higher incomes, and more education. Non-adopters were described in negative terms (e.g., 'laggards '), and were observed to be less educated or less well-traveled (20,130).

Diffusion studies of hybrid corn and other highly profitable agricultural technologies, such as commercial. fertilizer, in the 1940s and 1950s established the precedent for a ''classical diffusion model" in adoption research (42). By the 1970s, however, social scientists were beginning to find flaws in the classical model: 1) a ''pro-innovation bias, ' which caused researchers to view all innovations as improvements over existing practices; 2) an "individual-blame bias," when individuals did not adopt an innovation, rather than finding some fault with the "system" or change agent; and 3) overemphasis on centralized ''top-down' communication from researcher to successful farmer to rank-and-file farmer, with inattention to farmer-to-farmer information exchange as a means of disseminating information (128,77).

Although rural sociologists recognize shortcomings of the classical diffusion model, agricultural scientists in other disciplines may not be sufficiently informed about the limitations of the diffusion model. Many scientists' perceptions about farmer adoption of innovations are still shaped by the classical model, which may cause them to approach research and extension with the model's biases (24). A pro-innovation research perspective, however, could lead to unrealistic expectations about simple solutions, or ''technological fixes' for groundwater contamination and other environmental problems in agriculture. Too much emphasis may be placed on developing bio-engineered products, for example, at the expense of research on improving management practices and information delivery methods.

The pro-innovation perspective in agriculture also may help explain some researchers' and farmers' views that certain technologies, such as crop rotations, represent the "horse-and-buggy days" and are steps ''backward' for the farmer. Research and extension perspectives on the nature and desirability of innovations will influence the research base and educational approaches taken to encourage farmers to change behavior or practices (128,25,75).

five decades. Farmers who have interacted most with researchers in the past have frequently been members of specialized commodity groups, many of which sponsor ''commodity check-off programs' (16). Such programs generate research funds by allocating a small amount of money per commodity unit sold for commodity-oriented research. In addition, large farm operators with greater capital resources are recognized as being more capable of investing in new productivity-increasing technologies and are often considered to have better management skills than operators of smaller farms. As a result, agricultural researchers have had much more input from specialized producers with larger farming operations than from farmers with more diversified operations who may not view expansion as a high priority. In fact, researchers have had disincentives to seek advice of diversified farmers interested in reduced-input or nonchemical production methods, because these farmers are in the minority (141) and they are not viewed as traditional community opinion leaders. Furthermore, many diversified farm-

ers have been discouraged from approaching researchers about their information needs, because they perceive research and extension to be uninterested in and uninformed about alternative production methods (140). As a result, farmers who want to experiment with biological and cultural production methods largely have sought information and advice from each other.

Although early adoption and diffusion research in the 1950s identified peer groups as playing major roles in the technology adoption process, little research has been done on them since. Thus, information is lacking on their roles and effectiveness in disseminating farming practices (103). Recent social research findings provide insights on the types and sources of information farmers use when making farm practice changes, and these findings appear to be relevant to adoption of natural resource protection practices. Farmers appear to use three general learning techniques in considering farm practice changes:

1. informational learning through exposure to and gathering of information;
2. observational learning through examination of on-site farm practices; and
3. experiential learning through implementation, correcting mistakes, and additional practice (172).

Informational learning can be done through more formal, established sources of information, but observational and experiential learning tend to be achieved by observing different practices on one's own farm or other farms, comparing relative successes of various practices achieved by other farmers, and informal discussions with other farmers. In other words, the relevant source of information during technology adoption appears to shift when the farmer moves from an initial knowledge-gathering phase to a later phase when different practices are compared, selected, and implemented (103). Farmer-to-farmer networks could thus play important roles in helping farmers reduce the risk of adopting resource-protecting practices by providing social support, discussions with experienced peers, opportunities to observe field trials, and a site-specific structure in which to compare and test new practices.

The prevailing agricultural research and extension system has not facilitated broad farmer input into the research and extension process or mechanisms that promote and support peer-based learning among farmers. Technical assistance programs that promote on-farm trials and information transfer may be necessary to effect widespread farm practice changes to protect natural resources. Thus, if farmers are to achieve locally desired goals for resource protection in their areas, two kinds of research and information delivery may be needed to provide two very different types of support: 1) the prevailing research and extension system to develop new technologies and systems and disseminate technical information, modified to accommodate farmer-based experiential learning and facilitate communication from farmers to researchers; and 2) a farmer-based system that encourages on-farm recordkeeping, experimentation, and information-sharing and is actively supported by the research and extension system.

Need for a "Farming Systems Perspective" in Research and Extension

Additional criticisms have been raised about the U.S. agricultural research and extension system relating particularly to the lack of attention to farmer needs and constraints in technology adoption and natural resource protection. Critics have argued that:

- research topics and technological developments are derived from within scientific disciplines and are advanced because of professional rather than societal needs;
- little interdisciplinary interaction occurs among scientists, with resultant gaps in knowledge critical to the development of socioeconomic and technological bases for environmental protection in agriculture;
- researchers' tend to view all farmers as a homogeneous group, e.g., assuming that attention to the needs of a single commodity group is beneficial to all farmers;
- emphasis on capital-intensive technologies tends to skew research benefits toward larger farms (16);
- communication is lacking between farmers and researchers and little connection exists between the direction of researchers' efforts and farmers' needs (84);
- attention is lacking to dissemination and institutional processes that facilitate technology adoption (103); and

- **it is** assumed that traditional information dissemination methods are effective and solely in need of more sophisticated technologies, e.g., computers, teleconferencing (103).

These criticisms of the prevailing U.S. agricultural research and technology transfer process have been strongly articulated by researchers working in less-developed countries. In many of these countries, technical assistance methodologies like those implemented in the United States have been unsuccessful in increasing productivity because of farmers' socioeconomic and natural resource constraints (145,24). These observations have led to the development of other, more comprehensive research and extension approaches that focus on farmers, their constraints to technology adoption, and the socioeconomic and institutional contexts of farmer decisionmaking. These approaches are characterized by a ' 'farming systems perspective' that is intended to complement rather than replace the more top-down, technology-oriented research and extension approach (115).

Farming systems approaches include "farming systems research' (115,1 31) and the 'farmer-first-and-last' method in agricultural research and extension (24). Farming systems research is concerned with the ' 'optimization of the farming system as a whole' rather than optimization of production of a particular commodity (16), while the farmer-first-and-last approach strives to gain understanding of farmers' priorities and choices, then develop and refine strategies in collaboration with farmers (25). Farming systems approaches begin by considering farm practice changes in the context of farmers' social, economic, institutional, and environmental constraints. Although farming systems approaches originally were developed for use in other countries where resource constraints are more severe, many land-grant universities have recognized the relevance and usefulness of the farming systems perspective in the United States and have implemented farming systems research methods in local agricultural projects (115). A farming systems approach appears to be a highly appropriate method to facilitate adoption of natural resource protection practices, because this approach is based on an understanding of actual constraints to technology adoption.

Need for Increased Interdisciplinary Research Which Includes Social and Environmental Sciences

Research for enhanced decisionmaking is farmer-focused and interdisciplinary in nature, requires communication with farmers or other community members, and usually involves participation by social scientists. However, several constraints exist to increasing this type of research. First, definitions, methodologies, and protocols for interdisciplinary research in the agricultural and social sciences are not well developed. Increasing the amount of interdisciplinary research conducted in the agricultural research system, for example, will require clear definitions and criteria for the terms ' 'interdisciplinary' and ''multidisciplinary, ' which are different but often used interchangeably. Interdisciplinary research implies that scientists within several disciplines (and in some cases, nonscientist-members of advisory groups) interact in an organized fashion to assure that the overall research direction attempts to mitigate social conflicts and to address societal concerns relating to research implementation. Multidisciplinary research, on the other hand, implies that scientists from several disciplines contribute to the research but it does not imply that they work together or with other members of the nonscientific community to identify and resolve cross-sectoral or social conflicts in the research design (145).

Federal agency support for agricultural research expressly recognizes the importance of 'multidisciplinary" research, because applied problems are widely recognized to require collaboration among scientists from several scientific disciplines (96). However, the types and numbers of disciplines that should be involved in multidisciplinary research are not specified. As a result, the objectives, activities, and methods of multidisciplinary approaches like farming systems research have not been well-defined. The term "farming systems" thus has become a "catch-all" to include "any research that does not fall within the conventional, institutional categories of commodity or disciplinary research' (131).

Second, agricultural scientists may be reluctant to collaborate with social scientists or farmers on farmer-based approaches to protect natural resources, because traditional, disciplinary efforts toward developing productivity-increasing technologies are associated with the greatest academic and profes-

sional rewards. For example, site-specific research based on suggestions from farmer advisory groups is less likely to be published in more prestigious professional journals than it is in State agricultural experiment station bulletins and reports. Moreover, professional scientific societies typically have developed around individual disciplines and thus have less interest in mechanisms to support interdisciplinary research.

Third, less financial support has been available for research to enhance decisionmaking than for other production-oriented research areas. Federal competitive grants for agricultural research, for example, do not support work in the social sciences (103). As a result, funding sources for farmer-based approaches are most likely to come from State funding or from Federal formula funds, which are not necessarily allocated on the basis of social science needs. Support for research to enhance farmers' decisionmaking depends on the degree of State governments commitment to this type of effort, and some States have taken more steps in this direction than others. State support of farming practice demonstrations and on-farm experimentation to improve agrichemica1 management is particularly strong in Iowa, for example, which has made a policy commitment to agricultural resource stewardship.

Need for Increased Interdisciplinary Training and Education

State land-grant university and vocational agricultural education programs provide the research and education base for agricultural activities within each State. The State's agricultural schools train many of the people who become local agricultural professionals: farmers, agrichemical dealers, agricultural consultants, and public-sector workers in agricultural agencies. Thus, the agricultural education system can play a long-term role in enhancing the technical expertise available to farmers in responding to environmental concerns (box 5-K).

A key issue in enhancing the ability of researchers, extension workers, and educators to respond to multi-dimensional problems in agriculture is the need for interdisciplinary training that encourages professionals to think more comprehensively and inclusively. Researchers and technical assistance professionals with a broadened outlook will be more likely to cultivate interagency contacts and obtain information from a wider range of sources. This could increase interagency coordination, help avoid duplication, and expedite the flow of technical assistance to the areas that need it most. Enhanced decisionmaking by researchers and technical assistance personnel could be facilitated through: 1) interdisciplinary components in postsecondary education and professional programs, 2) pre-service or in-service training stressing interdisciplinary coordination and discussion, and 3) strong administration agency commitment to interdisciplinary communication and interaction.

Enhanced Decisionmaking for Groundwater Protection

Two-pronged technical assistance efforts, which use conventional and farmin g systems approaches, may be especially appropriate in providing farmers with information and support on appropriate farming practices in hydrogeologically sensitive areas. In areas where a groundwater contamination problem has been clearly identified, integrating the conventional technology transfer process with a farming systems approach could provide an improved understanding of the most relevant farmer constraints to adopting remedial practices. Involuntary groundwater protection programs, a farming systems approach thus could improve the effectiveness of educational efforts. In the case of regulatory programs, a farming systems perspective could help researchers and policymakers identify regulations that could be implemented more easily. Traditional extension and technical assistance approaches through CES and SCS will probably continue to be the best vehicles for providing farmers with technical information on patterns and severity of groundwater contamination, likely mode of contamination (point v. nonpoint source), and how management of the pertinent physical aspects of the farm could be changed to reduce contamination.

An initial prerequisite for an effective voluntary approach to reducing groundwater contamination is a clear definition of the contamination problem. However, the quality of information provided by technical assistance personnel will depend on the extent of State and local groundwater testing efforts and State commitment to understanding the problem. Additional prerequisites for effective voluntary programs are an in-depth understanding of current farming practices and farmer constraints, and support for farmers' observational and experiential validation of proposed farm practice changes. These latter requirements are best met through farming

Box 5-K—Integrating Postsecondary Agricultural and Environmental Education

Postsecondary undergraduate institutions in agriculture and natural resources (ANR) provide the bulk of agricultural training in the United States. Undergraduate ANR institutions are of three types:

- 74 land-grant colleges, established by two Acts of Congress in 1862 and 1890, and which belong to the Division of Agriculture of the National Association of State Universities and Land-Grant Colleges (NASULGC);
- 65 non-land-grant colleges, which belong to the American Association of State Colleges of Agriculture and Renewable Resources (AASCARR); and
- 45 forestry schools, with curricula accredited by the Society of American Foresters. Nineteen of these programs are offered by land-grant and AASCARR institutions (86).

In 1987, a total of approximately 78,000 baccalaureate students were enrolled in agriculture and natural resources programs in all ANR colleges. About one-tenth of these students were natural resources majors. About 57,000 of all ANR students were enrolled in land-grant colleges (36,37). This compares to a total 1988 undergraduate enrollment in all United States colleges of 7.8 million students, with an expected 2.7 million students expected to graduate from all high schools that year (26). Roughly one-tenth of one percent of all undergraduate students in the United States are enrolled in agricultural and natural resources programs.

Enhancing environmental technical assistance in agriculture requires consideration of the following questions:

- Who currently provides technical assistance to farmers and how have these persons been trained? Are these persons adequately trained in the agricultural and environmental sciences to help farmers achieve significant reductions in adverse environmental impacts?
- How can the current supply of agricultural assistance professionals improve their knowledge and skills in environmental and agricultural sciences?
- How can future agricultural science graduates be better trained in the environmental sciences and vice versa?
- Will the supply of future graduates meet the demand for increased environmental technical assistance in agriculture?

The following programs could enhance the environmental knowledge and skills obtained by students in ANR colleges:

- general environmental awareness courses;
- environmental studies minor programs, such as those offered by the University of Wisconsin and Rutgers University;
- professional programs in environmental sciences/studies;
- continuing professional education programs in environmental awareness/sciences; and
- agricultural teacher education programs with strong environmental components (86).

Some attempts have been made to include a "systems approach" to curriculum development and problem-solving in the agricultural sciences (1 1,1 76). The National Agricultural and Natural Resources *Curriculum* Project's Food and Agricultural Systems Task Group developed an education source book for faculty members wishing to encourage students to consider the broad range of socioeconomic and environmental impacts in coursework involving problem-solving (91). Efforts of the task force represent initial steps toward making ANR educational programs more comprehensive and likely to address social and environmental concerns.

systems approaches, including individual case studies, farmer surveys, support of farmer-to-farmer information networks, development of recordkeeping and planning tools for farmers, advisory services, and on-farm experimentation and demonstration plots. Iowa's Integrated Farm Management Program is an example of a well-developed farmer-based program with documented effectiveness in reducing farmers agrichemical expenditures and application rates (see box 5-I).

Planning and Objective-Setting

Traditional agricultural research and extension efforts in the area of farmer decisionmaking have concentrated largely on farmers' short-term or tactical decisions made throughout the crop production cycle (103). When research and extension have focused on more long-term farm management decisions, such efforts have emphasized development of production-related ''enterprise budgets' or assistance in making strategic decisions related to capital

investments and enterprise expansion. As a result, substantial gaps exist in knowledge and methods needed to make strategic resource protection decisions and to integrate production and resource protection objectives in farm management. Research and extension could provide increased support for strategic, long-term planning for agricultural resource protection and devote greater effort to estimating benefits and costs of resource protection efforts in both the short- and long-terms.

One promising approach to addressing these gaps is through the USDA Soil Conservation Service's concept known as ''progressive conservation planning, '' which encourages land users to go beyond implementation of single conservation structures to address all relevant resource management concerns on the farm (122). Since most land users come to SCS at first to obtain help with a single conservation practice (e.g., installing a grassed waterway to alleviate particularly severe gully erosion), a progressive planning process could help them consider more long-term resource protection objectives. However, SCS methods for progressive conservation planning do not appear to be well defined and other responsibilities typically are more pressing for SCS conservationists. Decisionmaking guidelines and a list of environmental and economic ''trade-offs' to consider in conservation planning could help landowners identify and begin to integrate production and resource objectives (161).

Some private organizations also have tried to address gaps in strategic resource planning assistance for farmers by developing planning methods and materials. For example, the Center for Rural Affairs in northeast Nebraska, has developed a ''Resource Audit and Planning Guide for Integrated Farm Management" (22,23). Another planning approach to long-term resource protection for range management, called Holistic Resource Management (132), also has applications for crop producers (88). Farmers' integration of long-term resource planning with crop production objectives will be facilitated by development and widespread use of educational and planning materials and methods.

Recordkeeping and Information Management

Demands for more and better information in agriculture have grown with concerns about controlling adverse environmental impacts, and resource protection goals will require farmers to take even more factors into account when making management decisions (72). Improved recordkeeping and information management tools would help farmers and other land users integrate their production and resource protection objectives. At the individual farm level, keeping records of the types, amounts, and locations of agrichemical use would enable farmers to track costs and benefits of nutrient and pest management inputs. At the aggregate level, agrichemical use records would help researchers evaluate agrichemical use patterns and their relationships to hydrogeologically vulnerable areas. Agrichemical use records thus could be used to identify areas where more intensive educational efforts or stricter regulations could be implemented to achieve the greatest improvements in groundwater quality.

Photo credit: U.S. Department of Agriculture, Agricultural Reward Service

Field scouts can monitor crop conditions and pest populations, providing farmers with more accurate information on pests to avoid unnecessary pesticide applications. Here, researchers check pheromone-baited traps in a peach orchard.

The collection and evaluation of records on aggregate agrichemical use will involve some type of reporting to a government agency. California currently is the only State in which private and

commercial agricultural applicators are required to keep records and report agrichemical use to the State. Many States require commercial applicators to keep records of agrichemicals applied for periods of 1 to 3 years, but few States require annual reporting. Outside of California, no State has a recordkeeping system to track the extent and locations of agrichemical use, nor does the Federal Government currently maintain a national agrichemical-use database. Better information on agrichemical use, which would help farmers and policymakers evaluate potential impacts of farming practice changes, could be obtained through voluntary or obligatory reporting programs.

Many members of the agricultural community, however, are deeply concerned about potential liability associated with government agencies' use of records in assessing agrichemical use patterns. Fear of liability thus could reduce farmers' participation in voluntary recordkeeping programs to the extent that any data collected would not provide a sufficient or accurate basis for improved policymaking. Farmers will be more likely to keep records and report agrichemical use voluntarily if they are exempted from liability or if they receive assurance that label-directed use will not make them liable for environmental contamination by agrichemicals. In the case of obligatory agrichemical use reporting, farmers might choose to reduce their liability concerns by having commercial applicators apply agrichemicals for them.

Computer and Information Technologies

State and local governments and agricultural extension need to use relevant and effective formats in presenting information to farmers on protecting groundwater and other natural resources. If information is presented in a format that is not used by farmers in resource-affected areas, it will not induce land users to make desired farm practice changes. In Iowa's Big Spring Basin project, for example, even traditional information formats such as extension pamphlets, field demonstrations, and trade fairs were used by a minority of farmers in learning about agrichemical contamination of groundwater (103). This needs to be considered when evaluating the potential effectiveness of newer formats such as computer models. If some traditional formats, which have been available for 50 years, are used by less than 20 percent of all farmers, it may not be realistic to expect widespread audience receptivity to newer formats (126).

Computer software programs can be important tools in improving agrichemical decisionmaking. The effectiveness of computer tools for use on the farm in improving agrichemical management, however, could be limited by the low percentage of farmers who own and use computers for farm management purposes. Roughly 12 to 14 percent of all farmers use personal computers, mainly for financial recordkeeping and tax purposes (72). Large farm operators presently account for most sales of agricultural software and this trend seems likely to continue in the future.

The private sector has been active in developing, selling, and supporting microcomputer software for such purposes as improving nutrient, pesticide, crop, and water management (e.g., Deane's Information Services) (32). Because the agricultural software market is small, however, it does not generate a high volume of demand. Thus, the trend is for the private sector to increase agricultural software costs per customer (85), which restricts agricultural software accessibility to producers who can afford it.

Some computer software and support services also are available to producers at little or no cost at CES and SCS offices. These include information systems such as SS1S (soil survey information systems) or software programs for improved agrichemical selection and management (box 5-L). Pesticide and nutrient management programs available from CES in some regions to improve agrichemical decisionmaking include:

- herbicide use decision-support packages, such as SOYHERB (124,80,71);
- Integrated Pest Management packages, such as the Field Crops Insect Management program (74); and
- plant disease decision-support packages, such as a computer-based advisory system for soybean plant diseases (137).

Expert systems for integrating whole-farm management are under development at the Univerity of Missouri (62), The Pennsylvania State University (8), and Michigan State University (58). A national research and development effort is also underway to implement a national Computer-Aided Decision-Support System (CADSS) that will attempt to integrate existing and evolving modules into a

Box 5-L-Soil Survey Information System

County soil survey reports, which contain information on the locations of different types of soils, are large, technical documents which are difficult and time-consuming to interpret manually. The Soil Survey Information System, or SSIS, is a computer software package developed for the State of Minnesota to quickly access the soil survey, relate it to a specific tract of land, and present the information in a graphic display or printout (6).

SSIS accesses soils information for one section of land at a time. (One section equals 1 square mile, or 640 acres.) Depending on information available, a county's SSIS program can incorporate physical and chemical properties of soils (soil texture, pH, organic matter), soil productivity, and groundwater pollution susceptibility by nitrates and some pesticides.

SSIS was developed at the University of Minnesota for use on standard microcomputers by extension and county government staff, State policy makers, students, and individual landowners. SSIS has been used principally to appraise individual land parcels, make recommendations on soils and crop management, and establish field eligibility for State and Federal conservation programs (i.e., Conservation Reserve Program), On farms, SSIS can be used to select sites for soil samples, improve fertilizer and herbicide management, and develop conservation and cropping plans. SSIS, currently only developed for the State of Minnesota, has been incorporated into another software program, SOILSAMP, which allows farmers to keep track of soil samples taken within fields.

SSIS maps can also be overlaid with other digitized maps such as land use, land ownership, vegetation, and drainage patterns, Map overlays are useful to county and State program officers to identify target areas, allocate resources or incentives programs, or concentrate educational efforts.

database system cross-linking information from several sources (60). CADSS will utilize national, regional, and local services of ARS, CES, and CSRS and include an environmental component.

Integrated research efforts on production systems also employ computer programs coordinated through artificial intelligence to produce information for farmers addressing multiple production and resource concerns (173). Although such systems may in the future provide more comprehensive information to farmers, their current use appears to be more applicable to developing basic computer systems technologies and identifying interactions in basic and applied research rather than meeting existing needs of individual farmers.

POLICY OPTIONS TO SUPPORT IMPROVED DECISIONMAKING ON AGRICHEMICAL USE

People who make decisions about nutrient and pest management in agriculture constitute a diverse group and include private applicators, commercial applicators, and the individuals who advise them. The commercial sector is probably just as important to consider as private applicators, because roughly half of all agricultural agrichemicals are applied by commercial applicators, and agrichemical dealers are responsible for advising large numbers of private applicators. A comprehensive approach to improving nutrient and pest management decisions to reduce agrichemical contamination of groundwater will consider activities by all types of agrichemical applicators and advisors. Comprehensive approaches to enhancing nutrient and pest management will include improved point-source controls, more efficient agrichemical application, and agrichemical use reduction through greater efficiency and nonchemical practices.

A variety of congressional options exist to provide assistance to private and commercial applicators, agrichemical dealers, and environmental advisory firms to reduce agrichemical contamination of groundwater. These options commonly require broadening of agricultural research, education, and technical assistance objectives, expanded information gathering, and increased agency coordination.

Options To Assist Agrichemical Applicators

Assistance can be provided to agrichemical applicators in several ways to improve nutrient and pest management decisions. The range of assistance available to applicators, however, will depend on the local ''mix" of State, local, and Federal education, demonstration, groundwater monitoring, and financial support programs. Assistance opportunities will be influenced by the degree of coordination and commitment among public-sector assistance personnel; expertise and services available in the private sector; and presence of farmer-to-farmer information and referral networks. The more oppor-

tunities that are available, the more likely applicators will be able to make nutient and pest management decisions that reduce agrichemical contamination of groundwater.

Publicly funded assistance programs can be designed to address needs of al! or only some of the applicators in an affected area. Intervention programs to assist farmers in changing practices to reduce groundwater contamination can begin by first obtaining profiles of the ''target' population of farmers in the area, their resources, constraints, and typical management practices. Such profiles can identify groups needing different assistance strategies, common mismanagement problems, and individuals who are likely to need more assistance based on their practices, available resources, and location relative to critical groundwater supplies.

Agrichemical Use Information

Many agricultural producers do not keep routine field records of the types, amounts, and locations of agrichemicals used. More accurate and complete agrichemical use information at the farm level would have two main benefits. First, agrichemical use information would help producers and technical assistance personnel evaluate whether excess or inappropriate agrichemicals are being applied and any costs involved. Second, aggregated information on agrichemical use would help policymakers evaluate impacts of proposed pesticide regulations or other agrichemical restrictions that could affect agricultural production. Voluntary or regulatory programs to track agrichemical use will call for agrichemical recordkeeping and some type of reporting system for evaluation.

Congress could direct USDA to develop and support on-farm agrichemical record keeping and reporting systems to facilitate agrichemical t racking. Agrichemical recordkeeping provides the means for farmers to quantify and evaluate nutrient and pest management costs. Recordkeeping may be the most important prerequisite to reducing the gap between actual agrichemical rates used and rates that are economically and environmentally optimal. Farmer-based assistance programs in Pennsylvania and Iowa indicate that recordkeeping efforts can reduce unnecessary expenditures for agrichemicals. Quantification of excess agrichemical costs could provide significant motivation for farmers to optimize or reduce agrichemical use.

Congress could direct USDA to conduct economic analyses of agrichemical use based on national and regional agrichemical use databases. Agricultural economists and other social scientists have insufficient information with which to assess economic impacts of proposed changes in agrichemical use, largely because so few data are available on actual types and amounts used at the individual farm level. Economics of nutrient and pesticide practices thus have not been studied sufficiently at the individual farm, regional, or national levels in order to make sound predictions about the feasibility of management changes. Since severe groundwater contamination problems may result in proposals to restrict, reduce, or replace agrichemicals in some areas, economic analyses based on actual agrichemical use could be used to determine courses of action most economically feasible for producers.

Information on Alternative Agricultural Practices

Producers and policymakers are asking for information on costs and benefits of alternative practices that could at least partially replace agrichemicals and on the distribution of these costs and benefits among farmers and agribusinesses. Currently available research includes: 1) economic returns derived from research plot data, 2) direct comparisons of economic returns from conventional farms with returns from farms using fewer agrichemical inputs, and 3) comparisons based on modeling (18). However, research on alternative practices and farming systems is limited and fraught with conflicting results, which may reflect the sensitivity of such research to assumptions about the economic potential of alternative practices (10).

Farmers who have implemented alternative practices can be found in nearly every region of the United States, although these farmers constitute a small minority. Case studies examining these farmers' experiences can identify promising alternative practices (96), but it is unlikely that the majority of farmers will adopt alternative practices rapidly, especially without better documentation of costs and benefits (141). Because additional time, labor, financial, and other management inputs usually are needed to achieve agrichemical substitution, the transferability of alternative farmers' successes or failures is difficult to predict without more comprehensive data from case studies.

Congress could direct USDA to assess and address research needs for conducting comparative economic analyses of agrichemical-based and alternative farming practices. Adequate economic documentation will be a key prerequisite for wider adoption of unfamiliar alternative practices and systems. Information from an assessment of comparative benefits and costs of agrichemical-based technologies and alternative practices would facilitate decisionmaking on farm practice changes. Research questions for such an assessment include: What types of alternative practices are being used as viable replacements for agrichemicals? What adjustments in management, crop choices, and production practices have farmers made to accommodate alternative practices? What were the costs involved and benefits gained? Valid economic comparisons are likely to require better accounting and valuation of nonpurchased inputs, environmental impacts, and beneficial and adverse interactions occurring in alternative production systems. Since alternative farmers typically produce a variety of commodities through diversified enterprises, economic analysis of alternative farming systems is less clear-cut than analysis of specialized commodity production. Thus, economic comparisons of alternative and conventional farming systems must be carefully designed, since USDA data on production costs are tracked on the basis of individual commodities and use of these data may be inappropriate in comparing conventional and alternative production systems.

Options for Applicator Certification and Training

The primary current means of encouraging proper management of commercial fertilizers and general-use pesticides is an ''honor system' based on customers' voluntary compliance with labeling instructions. Proper management of restricted-use pesticides (RUPs), on the other hand, is encouraged through labeling information and EPA and State requirements that all RUP applicators be certified or under the direct supervision of a certified applicator. Agrichemical management procedures and applicator training and certification programs are important areas for Federal and State Governments to assess in efforts to reduce agrichemical contamination of groundwater.

Obtaining an Overview of State Programs

EPA does not maintain a regularly updated national overview of State pesticide applicator certification and training programs. No national guidelines for the Pesticide Applicator Training program exist, and the quality of the training varies greatly by State. The lack of guidelines and a national overview makes it difficult to obtain an overall picture for assessing the status of applicator certification and training programs and their adequacy in addressing environmental concerns that are relevant to each State. Furthermore, EPA and most States can only roughly estimate the numbers of persons applying general-use pesticides in agriculture and of noncertified RUP applicators under the direct supervision of certified applicators. Better information on agrichemical applicators would enable policymakers to more accurately assess benefits and costs of providing enhanced certification and training programs. Better documentation and reporting on applicators also would provide incentives for improving agrichemical management.

Congress could authorize EPA to maintain a regularly updated national overview of State pesticide programs, including applicator certification and training requirements. The lack of regular Federal oversight on State applicator programs nationwide could hamper national responsiveness to environmental concerns related to pesticide use. Currently, a major obstacle to obtaining State information on a regular basis is the Federal paperwork-reduction regulation requiring Federal agencies to obtain permission from the Office of Management and Budget to send survey questionnaires to more than nine States at a time. EPA authorization to maintain national pesticide program overviews could provide a specific exemption from paperwork-reduction regulations for the purposes of assessing the status and adequacy of State pesticide programs, Alternatively, State reporting requirements to EPA could be expanded to include State program updates on a regular basis.

Congress could direct EPA and States to create and maintain a national database on pesticide applicators. States could require that the number of noncertified applicators supervised by each certified applicator be registered annually. States could annually report numbers and types of applicator certifications and numbers of noncertified applicators. Information on numbers of applicators would improve

benefit-cost analyses of proposed voluntary programs or regulatory changes to improve management skills and systematic oversight of pesticide applicators.

Congress could direct EPA and States to create and maintain a national database on agrichemical dealerships. States could report numbers and locations of licensed facilities. Accurate information on numbers of agrichemical dealerships would improve benefit-cost analyses of proposed regulatory changes regarding dealership facilities or employee training requirements.

Aiming To Reduce Agrichemical Mismanagement and Waste

Agrichemical mismanagement includes use of inappropriate agrichemicals or formulations, use of excess application rates, mixing or disposal in areas at high risk of contaminating water sources, application at inappropriate times or under wrong weather conditions, and improper disposal, all of which contribute to the release of unnecessarily high amounts of agrichemicals to the surrounding environment. The risk of agrichemical mismanagement appears to be high, and has potentially serious consequences in hydrogeologically sensitive areas. Information on the extent and types of agrichemical mismanagement, the situations and settings where it is most likely to occur, and the most cost-effective interventions for its reduction could aid development of technologies or programs to reduce agrichemical mismanagement and waste.

Congress could direct the USDA to conduct a national assessment of agrichemical management practices to identify certification and training needs for agricultural, commercial, and residential users. Information is scant on the extent and types of agrichemical mismanagement, its point-source or nonpoint-source nature, and its likely impacts on groundwater quality. A national assessment of agrichemical management practices could be similar to the national IPM assessment conducted in 1982-86. Information from this assessment could help identify high-risk areas and educational needs to prevent mismanagement. However, achieving good agrichemical management by all land users may not reduce groundwater contamination to the extent that health-based contaminant standards are not exceeded. This strategy does not address contamination due to climatic and technological-failure causes nor extreme cases of hydrogeological vulnerability of soils (133). Nevertheless, reducing agrichemical mismanagement appears to be a highly cost-effective strategy for addressing groundwater contamination in general.

An agrichemical management practices assessment could help determine the relative significance of point-source v. nonpoint-source contributions to groundwater contamination and the types of contamination sources that are most prevalent. Research to address these questions could include assessments of farmstead point-sources, livestock operations, and agrichemical dealerships and case studies to characterize point-source control practices and typical conditions of nutrient and pesticide storage and handling facilities. Nonpoint-source contributions could be assessed by determiningnutrient and pesticide application rates used by private and commercial applicators and the sources of information used for calculating application rates. Research to address these questions could include farmer surveys, interviews, and observational farm case studies. One problem likely to be encountered with farmer or applicator surveys and interviews is that responses are based on self-evaluation, which may not accurately describe the actual quality of agrichemical management. Nor are farmers and applicators likely to admit they are mismanaging agrichemicals. Findings from such research efforts may have to be interpreted in light of possible shortcomings and limitations of the research methodologies.

Assessing Federal v. State Financial Support of Applicator Programs

States currently provide 70 to 80 percent of applicator certification and training finding, and they are facing additional costs associated with new Federal pesticide program requirements. Since State and local funding sources are stretched increasingly to meet EPA requirements, States will have difficulty expanding applicator certification and training programs unless Federal funding is increased. The high level of public concern about agrichemical contamination of groundwater, however, may justify increases in Federal support for pesticide programs.

Congress could direct USDA and EPA to assess costs of expanded applicator certification and training programs based on a national assessment of certification and training needs. Stricter Federal requirements for agrichemical applicators would provide more incentives for proper management of pesticides nationwide, particularly if they

apply to agrichemical users who have previously not been required to be certified or trained. Clearly, use of applicator certification and training programs to reduce the potential for agrichemical mismanagement and groundwater contamination will require increased finding for applicator education. Benefit-cost estimates of expanded applicator certification and training programs could be used to inform policymakers and the public on the costs and trade-offs involved. Since program expansion cannot be achieved without concomitant financial support, such support may first have to be generated through informed public discussion and decision-making.

Another option would be for Congress to direct EPA and USDA to assess costs and provide funding for expanded applicator certification and training programs in hydrogeologically vulnerable areas only. Rather than supporting nationwide changes in applicator certification and training programs, Congress could call for expanded applicator programs solely in hydrogeologically vulnerable areas. More rigorous applicator programs could improve agrichemical management practices in these areas, especially if they were expanded to include applicators of fertilizers and general-use pesticides as well as noncertified applicators.

Alternatively, Congress could immediately increase Federal subsidies to States for applicator certification and training programs. Because accountability for pesticide applicator programs is shared by EPA, USDA, and the States; specifically earmarked funding and clear Federal directives may be needed to prevent weak, nonrigorous certification and training programs. If Congress wants EPA, USDA, and the States to strengthen applicator certification programs, regularly update applicator education programs, and implement additional training programs in IPM, reduced-input, and nonchemical approaches; it can expedite these changes by appropriating earmarked funding for these purposes. An alternative is to require EPA to fund the authorized 50-percent Federal share for States' pesticide programs, but this option will likely take EPA funding away from other areas. Congress also could authorize education programs for other types of applicators (e.g., private residential applicators). However, if USDA's and EPA's Pesticide Applicator Training program is to be strengthened and expanded, some resolution of the respective authorities of the two agencies must occur. Congress could put the authority and appropriations for PAT programs solely into USDA-ES or clearly define the respective responsibilities of the two agencies.

Options To Encourage Development of Private-Sector Services

Some producers may not have the skills, training, or time to identify or customize integrated practices on their farms to reduce agrichemicals' adverse environmental impacts. One mechanism for assisting farmers to reduce adverse environmental impacts is through private-sector advisory services (e.g., soil testing, pest scouting, IPM consulting). However, the supply of pest, soil, or crop advisors may be limited in some areas due to lack of education and training programs that could prepare trained personnel. Development of private-sector environmental services may also be hampered by lack of State licensing programs and potential liability concerns. State and Federal governments could play a role in facilitating the development of such services as one strategy to reduce adverse environmental impacts in agriculture. Development of private-sector environmental advisory services in agriculture could be fostered in several ways.

Congress could direct the USDA-Extension Service to provide extension training for agrichemical dealers. The Cooperative Extension Service could magnify its environmental education efforts by training agrichemical dealers, each of whom may advise hundreds of farmer-customers who purchase agrichemicals from them. The Federal Government, for example, might provide funding for at least one extension specialist per State to conduct agrichemical dealer training. Agrichemical dealer training could be designated as a temporary program to address specific groundwater concerns or it could be established as an ongoing education program to support dealer licensing, certification, or accreditation. In ongoing programs, CES could train employees in proper agrichemical storage, handling, and waste disposal procedures and equipment maintenance. A less costly alternative would be for Congress to authorize a single appropriation for USDA to develop dealer education materials which could be utilized by States CESs on a voluntary basis.

Congress could direct EPA and USDA to develop agrichemical dealership licensing guidelines for States. Dealership-based environmental

advisory services could be developed through State licensing, accreditation, or liability insurance programs. For example, licensing programs could require dealerships to provide IPM information or use IPM principles in all commercial services. States could also require agrichemical dealers to train employees in groundwater protection principles, IPM techniques, and other environmentally related topics as a condition for licensing or accreditation. Dealership licensing and accreditation guidelines could also include construction and maintenance specifications for commercial agrichemical storage, handling, and disposal sites. Implementation of the latter guidelines would likely require a State inspection system to verify dealership compliance.

Congress could direct USDA to conduct a national assessment to identify the need for and supply of private-sector agricultural services to reduce adverse environmental impacts by agriculture. Current capacity of commercial environmental advisory firms to offer farmers soil-testing, pest-scouting, and agrichemical-recommendation services may be inadequate to meet potential demand. USDA, in collaboration with the U.S. Department of Commerce, could obtain estimates of the numbers and types of agricultural service firms currently available and evaluate whether current training and development programs are adequate to provide sufficient service delivery. One mechanism to obtain such estimates would be through an Agricultural Services Survey similar to the one that was discontinued in the Census of Agriculture in 1979. Based on its estimates and assessment, USDA could identify training or support programs that would expand private-sector advisory services available to farmers. Support programs could include State accreditation or licensing for consultants and internship programs for agricultural and environmental science students.

Congress could direct the Small Business Administration to provide startup financing and training for small agricultural advisory firms. The Small Business Administration and Job Training Partnership Act programs could be vehicles for training and startup of environmental advisory firms that could expand the range of services to agricultural producers. New firm startups would help increase the supply of advisory professionals in the private sector and provide employment and training opportunities in rural areas. Training programs could be implemented at State or community colleges, and these could include pest scouting, soil testing, and crop and field monitoring services.

Photo credit: U.S. Department of Agriculture, Agricultural Research Service

Beneficial insects are mass-reared in laboratory cups to produce sufficient numbers for release in fields. Private firms and services supporting alternative methods of pest control are likely to increase with demand.

Congress could direct USDA's Extension Service and Agricultural Cooperative Service to conduct joint organizational training and support for farmer cooperatives formed to provide advisory services. The Agricultural Cooperative Service (ACS) is the USDA agency which provides organizational assistance to farmer cooperatives. The USDA could encourage the establishment of cooperatives, similar to Pennsylvania's Crop Management Associations, which help producers pool financial resources to hire their own field consultants. ES and the Economic Research Service could" complement ACS startup activities by providing cooperatives with assistance on agronomic, economic, and other technical aspects of cooperative advisory services.

Congress could expand USDA's Agricultural Stabilization and Conservation Service (ASCS) cost-share programs for integrated crop management. An ASCS integrated crop management program being tested in 1990 currently funds up to 100 farmers per State for cost-share assistance for advisory services to reduce agrichemical use and improve agrichemical management. One goal of this program is to encourage the development of private-sector advisory services. To this end, Congress could direct USDA to expand this ASCS program

and increase cost-share funding available for advisory firms.

Options To Improve Extension Support for Enhanced Decisionmaking

State CESs have suffered financial and personnel cutbacks in recent years, which will make it more difficult to meet the needs of individual farmers in addressing emerging environmental concerns. CESs could increase their technical assistance impacts by increasing coordination and cross-agency training between CES and other State and local agencies involved in agricultural and resource conservation.

Congress could direct USDA and encourage States to conduct cross-training of technical assistance staff in different agencies to foster coordination and consistency in information and assistance delivery. A variety of agencies provide information and technical assistance to producers on agricultural management and natural resource protection. However, technical assistance staff in one agency may not be aware of or use the educational materials and guidelines developed by other agencies. Effective use and implementation of educational and planning materials will depend on:

1. the validity and usefulness of water-quality information;
2. the degree to which all technical assistance staff understand and integrate the information into daily procedures;
3. staff skills in conveying new information and techniques to landowners; and
4. their degree of commitment in using the materials and convincing landowners of the importance and trade-offs of incorporating water quality into decisionmaking.

Thus, cross-training programs could include CES educational materials on water quality and agrichemical management, SCS guidelines for conservation cross-compliance plans and comprehensive resource planning, and ASCS materials on integrated crop management services. As a result, SCS conservationists would be more likely to use water quality materials at the field office level, and CES staff could play a greater role in supporting implementation of SCS's Resource Management Systems (RMSs). SCS and CES also could be encouraged to coordinate their efforts better with conservation districts and State government agencies to ensure consistent use of new water quality materials and resource planning guidelines. Furthermore, issue-oriented continuing education and training workshops could be used to develop staff capabilities in managing water quality programs. Such issue-oriented training could be an operating part of each agency's management programs. Career advancement or salary increases could be based on the successful completion of courses and training. Those who already have the training could test out of specific programs, to avoid wasting time on unnecessary review and to avoid being penalized for not participating.

Congress could direct USDA to develop and promote long-term natural resource planning assistance to help agricultural producers integrate environmental protection objectives into production decisions. Producers' integration of resource-protection and crop-production objectives could be facilitated by development of educational materials and planning methods for integrating natural resource protection measures. One promising approach to addressing these gaps is through SCS's "progressive conservation planning" concept, which encourages land users to go beyond installation of single conservation structures and to implement RMSs addressing all relevant resource management concerns. However, SCS methods for progressive conservation planning and RMS implementation do not seem to be well-defined and other agency priorities are typically more pressing for SCS conservationists. As a result, progressive conservation planning may not receive sufficient support or emphasis at the field office level. One possible strategy to increase RMS implementation is to educate local conservation committees about RMSs and the planning guidelines for achieving more comprehensive consideration of resource impacts during development of conservation plans. Education of conservation groups at the grass-roots levels could provide the "demand-pull" for more comprehensive resource management assistance from **SCS.**

Congress could direct USDA to assess the effectiveness of current methods used nationwide to disseminate information and technical assistance to producers on agrichemical contamination of groundwater and remedial farm practices. Alternatively, Congress could direct USDA to focus assessment of information and assistance delivery-systems in hydrogeologically sensitive areas. Site-specific information on groundwater quality and vulnerability is an important prerequisite

in identifying where, when, and how groundwater protection actions should be undertaken. Significant efforts are underway to define the extent of agrichemical contamination of groundwater and to generate knowledge of remedial practices, but little attention is being given to the effectiveness of different dissemination methods to encourage adoption of remedial practices where needed. Methods to disseminate information and encourage adoption of remedial farm practices must recognize the complexity of the technology transfer process and include efforts to understand the needs and capabilities of multiple target audiences. Further, eligibility for competitive grants for agricultural research could be expanded to allow assessments of different target audiences in designing effective programs to facilitate dissemination of remedial farm practices.

Overall, little is known on a national level regarding the capability of local assistance networks to define and specify the groundwater contamination problem. Thus, research on the adequacy of existing information and assistance-delivery systems could include assessments of:

1. the extent to which potential and actual groundwater contamination by agrichemicals is clearly defined and specified to farmers;
2. extent of research and extension's knowledge of viable farming practice changes to reduce contamination;
3. extent to which land users are currently being supplied with needed information and assistance; and
4. extent to which current research and extension methods recognize that different farmers need different types and sources of information.

Additional emphasis needs to be placed on ways to mobilize or modify existing information and education programs to address existing problems with existing technologies and management strategies.

In areas where agrichemical contamination of groundwater has been confined, the information and assistance delivery systems could be assessed and modified to increase the effectiveness of voluntary programs to change farming practices. Since such programs are likely to be more effective if they are based on an in-depth understanding of current farming practices and farmer constraints, a two-pronged approach (i.e., traditional "top-down" and farmer-based) to providing farmers with information and technical support may be especially appropriate for assistance programs in these areas. These approaches could include farmer surveys, case studies, support of farmer-to-farmer information networks, development of recordkeeping and planning tools for farmers, advisory services, and on-farm experimentation and demonstration plots. Integrating the traditional technology transfer process with a farmer-based approach could increase dissemination and implementation of remedial practices in these areas.

Options To Improve Research Support for Enhanced Decisionmaking

Redirected and coordinated research efforts would contribute to a better understanding of how farmers can be encouraged to protect natural resources in general and reduce agrichemical contamination of groundwater in particular. Effective voluntary approaches will be based on a good understanding of farmers' constraints and will require farmers' access to pertinent and usable information and adequate assistance.

Directing Research To Support Technology Adoption

Social, economic, and environmental factors will affect the adoption of practices that reduce agrichemical contamination of groundwater. However, agricultural research and development efforts often underemphasize these factors during development of technologies and management practices. Since agricultural practices that reduce agrichemical contamination will do little to improve groundwater quality if they are not widely adopted, research efforts could involve increased participation by social and environmental scientists in developing technologies and practices that can be successfully integrated into farming systems. Critical questions that should be answered for agricultural technologies as they are developed include:

1. are there likely to be social, economic, and environmental obstacles to adoption?
2. if such obstacles exist, what are they and how could they be addressed in implementation programs?
3. who are the proposed adopters and will the technology or practice be within their means? and
4. are the necessary institutional supports available to ensure continued use or operation of technologies if they are adopted?

Lack of attention to the ultimate target of research and development efforts is likely to result in peer adoption rates. Lack of institutional support, for example, has been identified as a key constraint to more widespread adoption of IPM techniques.

Congress could direct USDA to develop farmer "profiles" that would identify categories of farmers based on production practices, access to information, and constraints to adopting new technologies. Relevant characteristics to distinguish categories could include farm size, operating capital, and tenure as well as predominant crop and cropping system. Some of this information could be obtained from the National Agriculture Census and future Census' could be expanded to include key questions to provide the necessary information. Further, USDA's National Pesticide Use Survey could be expanded to include a ''Pesticide-Use Decisionmaking" component that could provide more specific information relative to agrichemical-use decisions. Farmer profiles could be developed frost at a national level to identify general categories and then refined further at the local level.

Broadening Farmer Input

Congress could direct USDA and the land-grant universities to assess roles of farmer-to-farmer networks and work with them in implementing use-reduction and nonchemical practices for groundwater protection. Informal groups of farmers have formed in several areas of the country in response to the issue of finding viable methods of reducing agrichemical inputs. One research option could be assessment of these local assistance networks and identification of ways to support their functions. Plans are being developed in many States to accelerate information and assistance through traditional university, extension, and conservation agency networks, but few are considering formal support for the development and maintenance of farmer-to-farmer information and assistance networks. One possibility would be to pay farmers for conducting field demonstrations or experiments related to reduced agrichemical use or nonchemical management practices in return for participation in a local network where experimental results were reported. Funds could be used to support dissemination of results in multiple formats both within and beyond the network. The role of government agencies and private-sector organizations in this process thus would be one of support rather than leadership.

Congress could direct USDA to assess current mechanisms for obtaining farmer input into development of BMPs and other farming practices and production systems. Despite criticisms that the traditional research and extension system is too "top down, " USDA is still considered a grass-roots agency and does incorporate some mechanisms for farmers to provide input to researchers and extension agents through local extension advisory committees, soil and water conservation commissions, and local commodity groups. However, the effectiveness of these traditional communication charnels in transmitting farmers' concerns and ideas to researchers and extension staff has not been adequately assessed. What are the roles of these groups? Who participates? How representative are these groups of whole populations of local farmers? Research on these traditional farm-based input groups could identify mechanisms by which these organizations could be made more effective or representative in providing research advice. Farmer-to-farmer networks are one mechanism to gain understanding of the concerns and constraints of different producer groups. Research administrators could facilitate researcher-farmer meetings and encourage involvement of a broader range of farmers in developing funding priorities for research and design of research extension activities.

Congress could direct USDA to develop protocols and criteria for on-farm field experiments. Several States have implemented demonstration programs involving on-farm experiments, technical assistance, and support of farmer-to-farmer networks. Current examples include the Sustainable Agriculture program of the Wisconsin Department of Agriculture, Trade and Consumer Protection; the Minnesota Department of Agriculture's Energy and Sustainable Agriculture On-Farm Demonstration Program; Iowa State University Leopold Center's cooperative relationship with the Practical Farmers of Iowa; and the California Energy Commission's Farm Energy Assistance Program. However, these programs do not provide sufficient incentives for large numbers of farmers to offset risks involved with field experimentation and most programs require farmers to go through a formal grant application and review process, thus limiting participation. As a result, these programs will have impacts only on relatively small numbers of farmers at first,

which will make it important for States to provide funding and personnel support for adequate dissemination of results. Federal or State funding for such programs could be increased on a short-term basis, with the intent that as soon as implementation of remedial technologies reaches pre-determined levels in target areas, funding could be phased out. Additionally, such programs could be established in areas of the country where groundwater contamination potential is high.

Facilitating Interdisciplinary Research Processes

Multidisciplinary and interdisciplinary research will become increasingly important in developing agricultural production systems that integrate social, economic, and environmental objectives. Multidisciplinary research involves specialists from several disciplines who contribute to the research but who do not necessarily work together to identify and resolve cross-sectoral conflicts between their separate research efforts. Interdisciplinary research, on the other hand, involves specialists from several disciplines who interact within the framework of a systematic, tested method to assure that the overall research effort is internally consistent and that foreseeable conflicts are identified and resolved.

Most land-grant university researchers have more incentives to conduct basic, disciplinary research than multidisciplinary or interdisciplinary research. Dearth of incentives to participate in collaborative research will likely impede development of farm practices which are suited to local environmental conditions. However, incentives for institutions which receive Federal funding for agricultural research may be changing. For example, funding for agricultural research by agencies other than USDA tends to be directed toward institutions exhibiting a capacity for interdisciplinary and multidisciplinary research. Although some incentives are changing, researchers will probably need further encouragement to engage in multidisciplinary and interdisciplinary collaboration.

Congress could establish an agricultural research task force with a mission to identify the obstacles to systems-oriented, interdisciplinary research within the agricultural research system. The task force could conduct an assessment of USDA and federally funded land-grant university research, and identify disincentives to interdisciplinary research arising from institutional structures, policies, or practices (e.g., proposal review requirements). The task force might expand its analysis to examine disincentives posed by professional advancement requirements (e.g., publication in peer-reviewed disciplinary journals). Based on this analysis, the task force could provide recommendations for encouraging adoption of interdisciplinary research approaches within the agricultural research system.

Congress could direct Federal agencies to develop research protocols and methodologies for conducting interdisciplinary agricultural research that integrate social sciences. Federally funded research programs recommend that persons experienced in managing and working on multidisciplinary teams evaluate multidisciplinary grant proposals and that at least one research team member be experienced in multidisciplinary research. Research programs could also include sociologists linked to delivery issues on project teams and peer review panels for proposals. Protocols and research methods could be designed by national scientific research organizations in collaboration with professional societies.

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Appendix 5-I-Selected State Agricultural and Water Quality Cost-Share Programs, 1988

State	Type of program	Administered by	Source of funds	Details
Alabama	Soil Erosion, Agricultural Water Quality, Forestry	Agricultural and Conservation Development Commission through the State Soil and Water Conservation Committee	State General Fund	Cost-sharing for soil and water conservation, agricultural water quality and reforestation. Established base allocation of 1°/0 of appropriated funds to each of the 67 districts. Remaining 330/. allocated on basis of problem identification.
Arizona	Range Improvement Cost Share	Apache Natural Resource Conservation District	General Fund	A State grazing lands cost-share program for specific range improvements on the Coyote Creek watershed. Cost-share percentages range from 10 to 95°/0 per improvement with a $10,000 maximum per lessee.
Arkansas	Water Resource Conservation Development Incentives	Soil and Water Conservation Commission	State Income Tax Credit	Up to $3,000 per year tax credit (l O-year limit) toward the construction or restoration of ponds, lakes (20 ac/ft. minimum), or other water control structures used for irrigation, water supply, sediment control, agriculture, or water management. A 3 year, 10°/0 tax credit of the costs incurred in switching from groundwater use to surface water.
California	Soil Survey	California Department of Conservation Soil Resource Protection Project	Special Fund	$240,000 per year for 5 years. Provides pass through funds to SCS to augment soil surveys in key agricultural counties of State.
Connecticut	Animal Waste Pollution Abatement	Connecticut Department of Agriculture through the USDA Agricultural Conservation and Stabilization Service (ASCS)	Annual Appropriation by General Assembly	Cost-share is limited to animal waste systems. The funds are used in conjunction with ASCS Agricultural Conservation Program funds. The total combined Federal and State cost-share amount cannot exceed 75% of the total costs of the system. Landowners apply for State cost-share funds at the local ASCS office. If the county ASCS committee approves the application, it is forwarded to the State ASCS committee. ASCS certifies completion and forwards the bills to the Connecticut Department of Agriculture for payment.
Delaware	General Conservation Practices	Department of Natural Resources and Environmental Control	Bond Act of the State of Delaware, 1985	Cost-sharing for erosion and sediment control, water quality, organic waste systems, water management, forestry, wildlife habitat development, and others. The program addresses both urban and agricultural concerns.
Florida	Agricultural Water Quality	Department of Agriculture and consumer Services, Bureau of Soil and Water Conservation	State General Fund	Cost-sharing for dairy operations in the lower Kissimmee River Basin to install Best Management Practices for animal waste management to reduce the phosphorus loading into Lake Okeechobee. Provides up to 75% State cost-share of actual project cost. Average $141,800 per project.
	Soil and Water Action Projects	Department of Agriculture and Consumer services, Bureau of Soil and Water Conservation	Florida Department of Agriculture and Consumer Services annual budget	Six projects funded for 1988-89: 1) Water Quality Study; 2) canal erosion and sediment control; 3) water conservation project; 4) plugging free flowing wells; 5) Environmental Learning Center; 6) National Weather Service Antenna.
Georgia	State Committee Technician Program	State Soil and Water Conservation Commission	Appropriations from State General Revenue funds	Conservation commission contracts with county governments to pay salary of conservation technicians. Technician is hired by county but trained and supervised by SCS. Local provides direction through its annual plan of operations. SCS provides office space, vehicle, and working tools. County pays all fringes and absorbs costs of any increase in salary above initial base salary determined by conservation commission.

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Appendix 5-I-Selected State Agricultural and Water Quality Cost-Share Programs, 1988-Continued

State	Type of program	Administered by	Source of funds	Details
Idaho	Agricultural Water Quality	Department of Health and Welfare and Idaho Soil Conservation Commission. Program is administered locally by soil conservation districts.	Water Pollution Control Fund financed by State taxes on cigarettes, alcohol, inheritance and sales tax	Up to $50,000 maximum cost-share per participant for Best Management Practices identified by soil conservation districts in the State Agricultural Water Quality Management Plan. Participants must be within the boundaries of an approved project area as identified in the State Agricultural Water Quality Plan.
	Resource Conservation and Rangeland Development Loan Program.	Idaho Soil Conservation commission in cooperation with local soil conservation districts.	A portion of inheritance tax collections.	Long-term (up to 15 years), low-interest loans (up to $50,000 at 69% or less) to farmers and ranchers for conservation improvements through local soil conservation districts. The conservation improvements eligible for the program are determined and adopted by the local soil conservation district. These measures may address resource needs for management of rangeland, riparian areas, irrigated and non-irrigated agricultural land on private and public land within the State of Idaho.
Indiana	Structural Measures	Division of Soil Conservation	Dedicated Fund-tax on tobacco products	—
Illinois	County Conservation Practices Program (CPP) Watershed Land Treatment Program (WLTP)	Department of Agriculture Division of Natural Resources	State General Fund, Bond Monies	CPP will be used to cost-share with farmers on instruction of enduring practices. WLTP will be targeted to high-priority watersheds for crest-sharing on enduring practices. Both programs are designed to assist in meeting the State goal of T by 2000.
	Erosion and Sediment Control	Department of Agriculture Division of Natural Resources	State General Fund	Cost-sharing only for landowners who have had a complaint lodged against them under the Illinois Erosion Control Law.
Iowa	Soil Conservation	Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation	State General Fund	Soil Conservation-State funds made available to pay up to 50%. of cost of approved permanent soil and water conservation practices. Mandatory practices installed to comply with the Iowa Erosion Control Law are cost-shared at 75%. A one-time payment of up to $1 O/acre will be made for a l-year contract to establish no-till, ridge till, and strip till. The district will make a one-time payment of $6/acre for contouring and $15/acre for contour stripcropping. The program also contains three special incentives features: 1. Special Watershed Projects: Permits cost-sharing up to 60% of the cost of a project where the owners jointly agree to a watershed conservation plan in injunction with their respective farm-unit conservation plans; 2. Summer Construction Incentives; 3. Management Practices: Allows the commissioners of a soil and water conservation district the option to allocate not more than 30% of a district's original and supplemental allocation for the establishment of management practices to control soil erosion on land that Is now rowcropped.
Iowa	Wind Erosion Control Incentive Program	Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation in cooperation with Department of Transportation	State Road Use Tax Revenue	One payment of $1 ,000/acre for fields with windbreaks (must be maintained 20 years); one payment of $500/acre for grass windbreaks (must be maintained 20 years); and one payment of $30/acre for Iowa till (must be maintained for 5 years).

	Conservation Practices Revolving Loan Fund	Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation	State General Fund	Under terms of the no-interest loan program eligible landowners may receive a maximum of $10,000 for installation of permanent soil conservation practices on their lands. A conservation plan must be developed by the soil conservation district and the project must be approved by the district. Revolving loan funds and public cost-sharing funds shall not be used in combination for funding a particular soil and water conservation practice.
	Water Quality Protection Projects	Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation	Lottery Funds	These projects will protect the State's groundwater and surface water from point and nonpoint sources of contamination, including but not limited to agricultural drainage wells, sinkholes, sedimentation, and chemical pollutants. Water protection fund resources will provide administrative, operational, and personnel support for the projects, and funds for management and structural measures to address identified water quality problems.
Kansas	Water Resources Cost-Share Program	State Conservation Commission	State General Fund	Provides up to 800/0 cost-share with landowners for enduring water conservation practices to improve water quality and quantity by the reduction of soil, water, and nutrient loss from the land.
	Water Resources-High Priority Cost-Share Program	State Conservation Commission	State General Fund	This cost-share program provides assistance to landowners for land treatment in identified areas of high-priority needs to develop and improve the quality and quantity of Kansas water resources with respect to rural flood management, agricultural water conservation, and nonpoint-source pollution.
	Water Resources-Watershed Planning Assistance Program	State Conservation Commission	State General Fund	Cost-share assistance for planning the development of a targeted watershed area to solve a high-priority long-term problem resulting from channelization processes over the last 20 years.
Maryland	Agricultural Water Pollution Control	Department of Agriculture; Department of the Environment	Chesapeake Bay Water Quality Loan Act of 1988	Water Pollution Control: Up to 87.5% (up to $10,000/project, $20,000/pooled project, $25,000/farm) cost-share for approved BMP for agricultural pollution control.
Minnesota	Erosion Control and Water Quality Management	Minnesota Board of Water and Soil Resources	State General Fund	Beginning 7/1/85 a variable cost-share rate is in effect. Up to 75%. for high-priority erosion, sedimentation or water quality problems; up to 50°/0 for less severe erosion problems. Cost-sharing eligibility is tied to land capability classification, erosion rate or distances from protected waters of the State. Specifically, land capability classes VI-VIII are excluded from cost-sharing eligibility.
	Reinvest in Minnesota (RIM)	Minnesota Board of Water and Soil Resources	General Revenue Bond-easements; State General Fund-program administration	The RIM program authorizes a State conservation reserve which pays landowners to convert marginal farmland to wildlife habitat or restore previously drained wetlands. Farmers may choose between 20-year and perpetual conservation easements in exchange for a single lump-sum payment. The 20-year RIM easement payment is 70% of the present value of average cash rent in the area. The payment for the perpetual easement is calculated as 100% of the present value of average cash rent in the area. Of the funds appropriated for the program, $750,000 is reserved for conservation districts to cover administrative and technical assistance costs.

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Appendix 5-I-Selected State Agricultural and Water Quality Cost-Share Programs, 1988-Continued

State	Type of program	Administered by	Source of funds	Details
Mississippi	Soil and Water Conservation	State Soil and Water Conservation Commission	General Fund	Rules and regulations have been developed and adopted by the Mississippi Soil and Water Conservation Commission. Five Soil and Water Conservation Districts will be chosen as pilot projects.
Missouri	Soil Erosion Control	Missouri Soil and Water Districts Commission	State FY-1982; Environmental Protection Agency, Continuing 208 funds. State W-83; State General Revenues; 1982 Constitutional Amendment No. 1 establishing the Third State Building Fund; and 1984 Constitutional Amendment establishing 0.1% sales tax for soil and water conservation	Up to 75% cost-share for eligible practices in conservation plan. Cost-share for lands eroding above tolerable soil loss limits, plus other special areas to encourage long-term, less intensive land uses.
	Soil and Water Conservation (Loan Interest-Share)	Missouri Soil and Water Districts Commission	1984 Constitutional Amendment No. 2	Interest drawn on State fund investments refunded to landowner for State's share or private loan for eligible practices. $2,500 to $25,000, loans qualify for interest-sharing, 10-year maximum. Predominant utilization of the program is for no-till equipment (maximum term, 5 years).
	Soil and Water Conservation (SALT: Special Area Land Treatment)	Soil and Water Districts Land mission	1984 Constitutional Amendment No. 2	Program combines benefits of State cost-share program and loan interest program for landowners within locally identified higher priority watershed areas of 1,000 to 4,000 acres needing treatment. Loan interest-share assistance for landowner portion of cost-share practices to carry complete farm Resource Management Systems (RMSS) plus loan interest-sharing for practices in RMSS not qualifying for cost-sharing. Program also provides an annual grant to districts for demonstration/Information/Technical needs to support the project. SALT projects are funded for 5 years.
	Wildlife Habitat Improvement	Missouri Soil and Water Districts Commission	Conservation Sales Tax Amendment (1977)	Additional incentives to farmers who complete wildlife habitat and warm season grass practices on Conservation Reserve Program (CRP) acreages. The incentive is 25% of average county costs of eligible practices.
	Native Prairies Restoration Incentive	Missouri Soil and Water Districts Commission	Conservation Sales Tax Amendment (1977)	Additional incentive available in four test counties to promote soil conservation and wildlife improvement through restoration of native prairie areas. The incentive is available for 2 years at $20/acre year with a 5-year maintenance period.
Montana	Range Improvement Loan	Department of Natural Resources and Conservation, Conservation District Division	Renewable Resource Development Fund-Coal Severance Tax Revenues	Rangeland Improvement bins-Up to $20,000 low-interest loan exclusively for improving rangeland conditions. Administered locally by conservation districts. (Loans currently at 4%).
	Conservation District Grants	Department of Natural Resources and Conservation, Conservation District Division	Coal Severance Tax Revenues	Grants to conservation districts (CDs) for projects and/or equipment to promote on-the-ground conservation, Maximum grant $30,000.
	Conservation District Grants	Department of Natural Resources and Conservation, Conservation District Division	Resource Indemnity Trust Funds	Grants to CDs for district administration. Provided to CDs whose county mill levy is not sufficient to finance all administrative expenses.

	Conservation District Riparian Management Grant	Department of Natural Resources and Conservation, Conservation District Division	Renewable Resource Development Fund-Coal Severance Tax Revenues	Grants to CDs for demonstration type projects showing proper riparian management practices. Program will emphasize nonstructural type practices.
	Renewable Resource Development Grants	Department of Natural Resources and Conservation, Water Resources Division	Coal Severance Tax Revenues	Grants to public entities (e.g., CDs) for development of renewable natural resources.
	Conservation District Agricultural Energy Conservation Grants	Department of Natural Resources and Conservation, Conservation District Division	Oil Overcharge Funds from U.S. Department of Energy-State Energy Conservation Program	Grants to CDs for projects that conserve energy and promote sound soil and water conservation practices.
Nevada	Energy Demonstration	Conservation Commission	Exxon Oil Overcharge Funds	The conservation commission awards grant funds to CDs for energy demonstration projects. The projects have been associated with photovoltaic and infrared technology and their uses in agriculture. To date about $73,000 have been awarded.
Nebraska	Soil and Water Conservation	Nebraska Natural Resources Commission	State General Fund	Water Resources: Up to 75% cost-share for water impoundment structures, terraces, outlets, irrigation reuse pits, grass seeding, tree planting, diversions, grade stabilization structures, sediment control basins, and planned grazing systems.
New Jersey	Farmland Preservation, Soil and Water Conservation	New Jersey State Agriculture Development Committee and New Jersey State Soil Conservation Committee (through local conservation districts)	Bonds of the State of New Jersey :Totalof $50,000,000 authorized-88% for purchase of development easements; 120/. for cost-sharing with farmland owners.	Bonds sold to initiate Farmland Preservation Fund for providing up to 80°/0 State share, 20°/0 county share of cost of acquiring development easements on farmlands and or 500/0 costs of approved soil and water conservation projects. Land must be enrolled in a Voluntary Agriculture District as designated by the Agriculture Retention and Development Act to be eligible for soil and waler conservation cost-sharing. Conservation projects must be approved by the State Soil Conservation Committee, cost-share practices must be part of conservation plan approved by the local soil conservation district.
North Carolina	Agricultural Cost-Share Program	Department of Natural Resources and Community Development, Division of Soil and Water	State General Fund	Begun as a pilot program in FY 1984-85. Has now been expanded statewide and is currently available in 56 of 100 counties. Cost-share of 75%, up to $1 5,000/year/applicant, for specified practices including conservation tillage, diversions, field borders, critical area plantings, sediment control structures, sod-based rotations, grassed waterways, stripcropping, terraces, cropland conversion to grass or trees, grade control structures, water control structures, and animal waste management systems that reduce the input of agricultural nonpoint source pollutants into the waters of the state. Annual and long-term (3 year) agreements available.$825.000 goes to local conservation districts on a 50/50 cost-share basis to hire additional technical assistance.
	Tax Credit for Purchase of Conservation Tillage Equipment for Agriculture and Forestry	Tax Commission	N/A	Provides for a State income tax credit of 25%, or up to $2,500/year (the lesser) for the purchase of conservation tillage equipment for use in agriculture and or forestry. The amount of the tax credit may not exceed the individuals tax liability for the year. Excessive credits may be carried forward to the next 5 tax years.

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Appendix 5-I—Selected State Agricultural and Water Quality Cost-Share Programs, 1988-Continued

State	Type of program	Administered by	Source of funds	Details
North Dakota	Wildlife Cost-Share Program	Game and Fish Department	Interest money earned on Game and Fish Reserve Funds	Wildlife-Provides 75 to 100% of funds for practices which improve water quality and enhance wildlife habitat.
Ohio	Agricultural Pollution Abatement	Department of Natural Resources, Division of Soil and Water Conservation	Capital Improvements Fund	Cost-share for installing enduring practices for reducing agricultural sediment pollution at not less than 75%. of cost, but not more than $5,000 for animal waste management and erosion control.
	Natural Resource Protection	Ohio Department of Natural Resources, Division of Soil and Water Conservation	Capital Improvements Fund	Provides up to 50% State funding of works of improvement to promote natural resource management including erosion control, drainage and flood control, water quality and water supply, wildlife enhancement, streambank stabilization.
Oklahoma	Soil Erosion and NPS Pollution Prevention	Oklahoma Conservation Corn mission		Effectively broadens the duties of the Oklahoma Conservation Commission (OCC) and the Conservation Districts. Authorizes OCC to act as management agency having jurisdiction over, and responsibility for, directing nonpoint source pollution abatement programs outside the jurisdiction of cities and towns. It also empowers OCC to administer a cost-share program which would provide State funds to CDs for carrying out conservation or management practices on the land to benefit the public through prevention of soil erosion or nonpoint-source pollution. The program is administered locally by CDs.
Oregon	Discretionary Grants, Senate Bill 617 planning Funds, District Operation Funds	Oregon Departmentof Agriculture, Soil and Water Conservation Division	State General Fund	Funds for discretionary grants; planning grants; district operations; confined animal feeding; and Interagency Clean Water Program.
Pennsylvania	Chesapeake Bay Agriculture Program Financial Assistance Funding Program	State Conservation Commission Bureau of Soil and Water Conservation	State-General Fund Federal-EPA Chesapeake Bay Program	Purpose of the Financial Assistance Funding Program is to assist landowners with the cost of installing practices to manage the disposal and application of nutrients on land areas that are responsible for nonpoint-source pollution. First priority is given to those high- and medium-priority watersheds identified in the "agriculture and earthmoving plan" developed under the 208 program, and other areas the Commission determines are high priority based on additional surveys and studies. The cost-share program is administered by the State Conservation Commission cooperatively with conservation districts and the USDA Agricultural Stabilization and Conservation Service.
South Carolina	Forest Renewal	Forestry Commission	Forest Renewal Fund (funded with State appropriations and assessment on forest products; 4:1 ratio-forest products: State appropriations)	Reforestation: Funds to provide site preparation, natural and artificial reforestation or stand improvement on up to 100 acres per landowner.
South Carolina	Tax Credit-Conservation Tillage and Drip/Trickle irrigation Equipment	Tax Commission	N/A	Conservation Tillage and Drip/Trickle Irrigation Equipment: Claim a 25% tax credit on expenditures (up to $2,500/year) for purchase of conservation tillage equipment, drip/trickle irrigation systems and dual-purpose truck and crane equipment; a one-time credit.
South Dakota	Shelterbelt Incentive Program	South Dakota Department of Agriculture Division of Conservation	State General Fund matched by State Game, Fish and Parks (GF&P) Funds	Program pays $5/acre for new tree plantings or renovations for a contract period of 10 years during which tree plantings must be maintained.

	Conservation Project Grants	South Dakota Department of Agriculture Division of Conservation	State General Fund	Funds used to cost-share conservation projects on a matching 50/50 basis.
Utah	Revolvingbxm-Agricultural Resources Development Loan	Utah soil Conservation corn mission	State General Fund; interest on loans	Provides low-interest loans for agricultural and energy conservation, range improvement, and watershed development. One-time 4%. administrative fee; 3%. per annum interest rate.
Vermont	On-Site Sewage Program	Vermont Association of Conservation Districts, Natural Resource Conservation Districts	State Appropriation and User Fees	Service program to help towns administer ordinances regulating single-family home on-site sewage systems. Assistance in adopting, administering and enforcing local ordinances. Septic system evaluation, planning, design and inspection services provided. Program supported by user fees and appropriations from the State legislature.
Virginia	Reforestation of Timberlands	Division of Forestry	1/2 Reforestation of Timberlands State Funds; 1/2 Forest Products Tax	Reforestation-Up to 50% ($60/acre) for site preparation and planting seedlings for commercial species of pines.
	Chesapeake Bay Agricultural BMP Program	Department of Conservation and Historic Resources, Division of Soil and Water Conservation	Commonwealth of Virginia EPA Chesapeake Bay Program	Variable percentage or flat rates. State cost-share assistance alone or combined with ACP cost-share rate not to exceed the maximum rate established by the State ASCS Committee. Eligible practices include animal waste control facilities, diversions, grass filter strips, conservation tillage, vegetative cover on critical areas, sediment retention, erosion or water control structures, sod water, stream protection, stripcropping, terraces, conversion of marginal cropland to pasture or forest. flat rate rest-share practices funded only by State.
	Statewide Agricultural BMP Program	Department of Conservation and Historic Resources, Division of Soil and Water Conservation	Commonwealth of Virginia	Variable rate and flat rate cost-share incentives for selected BMPs in Virginia's Agricultural BMP cost-share manual. Soil and water conservation districts administer this water-quality program locally to control sediment and nutrient loss and animal wastes.
	Tax Credit for the Purchase of Conservation Tillage Equip ment		N/A	Provides for a 250/~ State income tax credit, up to $2,500, for individuals and corporations for the purchase of conservation tillage equipment, defined as a no-till planter or drill. If the tax credit exceeds the tax liability for that year, the excess may be carried over for credit in the next five succeeding taxable years until the amount of the tax credit has been taken,
Washington	Nonpoint Water Quality Matching Grants for Conservation Districts	Washington State Conservation Commission	Centennial Clean Water Act Biennial Appropriation	Makes available to the Washington State Conservation Commission 2.50/. of the Centennial Clean Water Act's biennial appropriation to provide matching grants to conservation districts. The grants will be used to implement locally identified projects that address nonpoint water pollution problems identified in the districts' annual plans of work. All grants require a 25%. local match. Although the Commission does not require a county match, it will add bonus points during project evaluation for district proposals containing evidence of at least a 5% cash or in-kind match from county government.

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Appendix 5-I-Selected State Agricultural and Water Quality Cost-Share Programs, 1988-Continued

State	Type of program	Administered by	Source of funds	Details
Wisconsin	Soil and Water Resource Management Program	Overall administration by the Department of Agriculture, Trade and Consumer Protection with planning and project implementation activities administered through county Land Conservation Committees (LCCS).	State General Purpose Revenues	Program goal is T by 2000. A soil erosion control plan is prepared by targeted, high erosion counties, with program funds providing up to 50% of the cost to prepare the plans. After the Department approves a plan, a county may apply for implementation funds for cost-sharing, technical assistance, information and education, and other soil and water resource management activities.
	Farmland Preservation Income Tax Credit Program	Local--County Government State-Department of Agriculture, Trade and Consumer Protection; Department of Revenue	Wisconsin General Fund	The program provides a mechanism for farmers subject to farmland preservation agreements or exclusive agricultural zoning (with soil conservation requirements) to receive an income tax credit based on a formula which takes into account farm income, property taxes, and income taxes paid.
Wisconsin	NPS Pollution Abatement	Department of Natural Resources	Wisconsin General Fund	NPS Water Pollution Abatement-Up to 75% of cost of BMPs identified in 208 Water Quality Management Plans for both urban and agricultural NPS problems. Funds must be spent in priority watersheds established in 208 planning effort.

SOURCE: National Association of Conservation Districts, Washington, DC.