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# Agricultural and Water-Quality Conflicts

## Economic Dimensions of the Problem

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Water Quality

*Modern farm production practices, which use agricultural chemicals, benefit consumers through lower prices and increased output. Consequences of agricultural production, however, such as soil erosion, chemical runoff and leaching, and wetlands conversion, may impair surface and ground water quality. These off-farm water-quality effects impose costs on society, including damage to fish and wildlife resources, costs of avoiding potential health hazards and preserving natural environments, and lost recreational opportunities. This report summarizes conflicts between agricultural production and water quality and discusses policies that stress the use of economic and technical assistance incentives to encourage adoption of pollution-reducing farming practices.*

Agricultural production may adversely affect the environment. Fertilizers and pesticides used to grow crops may leach through soils and contaminate ground water supplies. Dissolved chemicals in drinking water may then pose a human health risk. Runoff of chemicals and sediment from cropland, as well as soil erosion, may impair the quality of streams, lakes, and rivers. Many valuable ecological functions served by wetlands, especially filtering sediment and nutrients in runoff, may be lost when wetlands are converted to agricultural production.

When water quality is impaired by agricultural production, society bears a cost not fully reflected in the market prices for agricultural products and inputs used in producing them. These costs include damage to fish and wildlife resources, which have both recreation and commercial use, increased water treatment costs, and lost recreational opportunities (see box). Assessing the tradeoff between costs of water-quality impairments and benefits of agricultural production is difficult because direct measures of market value are not available for most water-quality impairments. Indirect measures of environmental value must be used.

Despite fairly widespread detection of nitrates and pesticides in drinking water supplies, only a small proportion of the Nation's wells appear to contain pesticides or nitrates in amounts thought to pose a risk to humans. Estimated cost to monitor for agricultural contamination of ground water supplies on a one-time basis is between $890 million and $2.2 billion. Agricultural sources of surface water contamination are fairly widespread, but the severity of the problem also varies among regions. Information on economic costs of these impairments is incomplete, but estimated costs range from $2-$8 billion per year.

Policymakers are considering legislation that will help reduce agricultural sources of water-quality problems, while protecting profitable production of food and fiber. New initiatives from USDA, the Environmental Protection Agency, and State governments stress the importance of voluntary adoption by farmers of pollution-reducing agricultural practices. Farm legislation enacted in 1990 has provided incentives and limited financial support for programs that retire environmentally sensitive land from production, reduce chemical use, and encourage adoption of less-polluting farming systems.

### Tradeoffs Between Agriculture and Water Quality

America's farms provide an abundant supply of food and fiber, but off-farm consequences from impaired water quality can impose costs on society.

- Off-farm effects on water quality impose costs on society, including costs of avoiding potential health hazards, degradation of natural environments, and lost recreational opportunities.
- Since these off-farm costs are not directly revealed through market prices, farmers may not consider them in private decisions on production choices.
- Evaluating economic costs of water-quality effects requires sophisticated economic valuation techniques. Available evidence indicates that these costs may be several billion dollars per year.
- Agriculture is only one source of water pollution, and efforts to protect surface and ground water resources must be carefully designed to maximize expected economic benefits while minimizing costs to farmers and consumers.

# Introduction and Overview

**Increasing public concern about conflicts between agriculture and water quality has led to policies intended to protect both the environment and farm profitability.**

The potential for agricultural chemicals and sediment from cropland to reduce the quality of America's surface and ground water resources has become a priority issue for numerous public and private organizations, including the U.S. Department of Agriculture. Conflicts between production of food and fiber and prevention of environmental pollution have received new attention, and new policies and programs have been developed to address these issues (see box).

Use of chemical fertilizers and pesticides increases agricultural output and has helped boost agricultural production worldwide by 60 percent since the mid-1960's. However, chemicals remaining in the soil after application to cropland may move through the soil to underground drinking water supplies. Soil erosion and cropland runoff may move chemicals and sediment to adjacent lakes, rivers, and estuaries, impairing both wildlife and human use of these waters. Wetlands provide habitat for a variety of wildlife species and serve other important functions, such as flood control, but wetlands are degraded by agricultural runoff, and their functions are lost through drainage and conversion to cropland.

### Concern About Ground Water Quality Increases

Until recently, little was known about agricultural chemical residuals in ground water. Discovery of nitrates and pesticides in ground water during the late 1970's and early 1980's dispelled a commonly held view that ground water was protected from these chemicals by layers of rock, soil, and clay. At least some quantities of 46 pesticides have been detected in drinking water wells in 25 States (Williams and others, 1988). The Environmental Protection Agency (EPA) recently completed a nationwide study of drinking water wells showing that 1.2 percent of community water systems and 2.4 percent of rural private domestic wells sampled in the survey contained nitrates at levels higher than EPA's recommended levels. About 10 percent of community wells and 4 percent of domestic wells tested contained detectable levels of one or more pesticides (U.S. EPA, 1990).

### Surface Water Pollution From Nonpoint Sources Receives New Emphasis

The contribution of soil erosion and cropland runoff to surface water pollution has long been recognized. Most early efforts to protect surface water quality, however, were directed at municipal and industrial sources of pollution where a single pollutant source could be identified. With enactment of the 1987 Water Quality Act, new emphasis is being placed on controlling nonpoint sources, such as runoff from cropland and forest land, where there is no single identifiable source of pollution. Recent studies in the Midwest suggest that some farm chemicals may wash off cropland and end up in lakes and streams at rates greater than suspected (Goolsby, Coupe, and Markovchick, 1991).

### Protecting or Restoring Wetlands May Conflict With Agricultural Production

Provisions of the 1985 Food Security Act designed to protect wetlands (commonly termed "Swampbuster") deny farm program payments to producers who convert wetlands to agricultural production. Controversy over how to implement the recent policy goal of "no net loss of wetlands" has highlighted the conflict between uses of wetlands for wildlife habitat and other environmental or ecological services and their uses as productive cropland. Difficult issues, such as defining wetlands, the value placed on them, the degree of restoration needed, and property rights, have complicated public decisionmaking in this area.

### Protecting the Environment From Agricultural Pollution Implies Tradeoffs Among Social Objectives

Programs and policies to prevent environmental degradation from agricultural sources must balance public and private benefits with costs of improved environmental quality. Reducing farm chemical use, controlling soil erosion, and protecting wetlands may generate economic benefits from improved environmental quality. Such changes in production practices, however, may raise farmers' production costs, and possibly increase food and fiber costs to consumers. Programs to protect the environment must be carefully designed and implemented to balance the goal of improving environmental quality with the need to minimize costs of preventing pollution.

## Programs and Policies To Protect Water Quality From Agricultural Sources of Pollution

Policy initiatives reflect an increasing commitment to accommodate environmental concerns while minimizing the costs to farmers and the public of protecting water quality.

### USDA Water Quality Activities

- Food Security Act of 1985 provisions:

  *Conservation Compliance*
  *Sodbuster*
  *Swampbuster*
  *Conservation Reserve Program (CRP)*

- Agricultural Conservation Program (ACP)
- Conservation Technical Assistance (CTA)
- Extension Service activities
- USDA Low Input, Sustainable Agriculture (LISA) activities

### Other Programs and Policies

- EPA programs provide technical guidance, water-quality standards, and some financial support for State and local water pollution control efforts.

  *1987 Water Quality Act Nonpoint Source Programs*
  *Pesticides in Ground Water Strategy*
  *Safe Drinking Water Act: Standards for Chemicals in Drinking Water*
  *Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Regulation of Agricultural Chemicals*
  *1991 Coastal Zone Management Act (CZMA) Nonpoint Pollution Provisions*

- State efforts implement Federal policies, and may also include innovative State-level pollution control legislation and programs tailored to meet local needs.

  *State Nonpoint Source Management Plans filed in accordance with 1987 Water Quality Act and the 1991 CZMA Amendments*
  *State ground water protection plans*
  *Fertilizer tax and funding of LISA*
  *Monitoring ground water for trend and frequency of contamination*

# Environmental Quality Problems Arising from Agricultural Sources Impose Costs on Society

**When water resources are degraded by agricultural chemicals and sediment, the pollution imposes costs on society that are not considered in farm production decisions.**

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The fundamental economic issue concerning agricultural impairments of environmental quality reflects divergence between private and public costs. When making production decisions, farmers balance their expected private costs of various production options, including tillage practices and chemical use, with returns from crops produced. However, farmers' decisions may have unintended effects far removed from their private fields; consumers of water resources or other environmental services, such as recreation, may bear the costs when agricultural runoff, sediment, or farm chemicals degrade the quality of these resources. Though the public may place a value on these lost services, this value is not fully reflected in private costs farmers pay for farm inputs or in farmers' cost/benefit calculations in deciding how to produce a crop.

## Full Economic Costs of Agricultural Chemicals Not Reflected in Their Market Prices

Economic losses from impaired environmental quality reflect, in part, the value of the services the resources provide. When the value of these services is impaired by agricultural chemical pollution, these losses can take a number of forms, including costs of providing alternative sources of drinking water, increased treatment costs for public and private water systems, lost boating and swimming opportunities, and damage to valuable recreational and commercial fishery resources. The total social cost of farm chemicals includes these environmental costs as well as private market prices. The prices paid by users of agricultural chemicals, then, do not fully reflect their full social cost.

## Economic Costs of Impaired Water Quality and Wetland Conversion Difficult To Measure

The wide array of environmental effects of agricultural chemicals makes valuation of these effects difficult. Economic costs of degraded surface and ground water depend on many factors, including the population affected by impaired water quality, uses of the water resources, and value placed on those uses by consumers. In a similar vein, economic benefits of the services provided by wetlands, such as recreational use and value placed on the existence of wildlife habitat, are frequently not measurable in the marketplace.

Without direct, observable measures such as market prices, indirect measures of economic costs of impaired wetlands must be used, such as statistical techniques to measure willingness to pay for improved recreational opportunities (see box). Economists also use nonmarket valuation methods to measure the value of environmental resources not based on consumption or use. For example, individuals may place a positive value on the existence of clean water or preserved wetlands even if they do not directly use the resources themselves. Better estimates of economic costs require additional research into relationships between agricultural production and environmental effects.

## Economic Costs of Water-Quality Impairments

Market prices do not reveal all the costs of impaired water quality; therefore, these costs must be estimated using indirect measures.

### Ground Water

- Many concerns about agricultural chemicals in ground water arise from uncertainties about health effects of human exposure to low levels of pesticides and nitrates in drinking water. These health effects are poorly understood.

- The extent of ***actual contamination*** (as opposed to the weaker measure of ***vulnerability to potential contamination***) is unknown, making quantification of these health effects more difficult.

- Placing dollar values on the increased risk of death or illness from human exposure to hazardous chemicals is very controversial. Indirect measures, such as willingess to pay for clean water, are available for some specific sites, but aggregate measures of the total cost of impaired drinking water supplies are not available.

  ***One measure of costs of potential ground water contamination is the cost to consumers to avoid risk of exposure through monitoring of drinking water wells and provision of alternative supplies of clean water.***

### Wetlands and Other Surface Water Bodies

- Some direct measures of the cost of water pollution are available, such as the cost of treating municipal drinking water supplies for sediment, bacteria, and nutrient enrichment.

- Other damage, such as loss of recreational opportunities, is to goods and services for which no formal market exists; prices are therefore unavailable as indicators of the value of these goods and services to society.

- Some damage from nonpoint source surface water pollution and loss of wetlands is to the surrounding ecosystem, such as degradation of wildlife habitiat and loss of fish stocks. Society may place a value on this environmental effect even if the water systems are directly used only by a few anglers or boaters.

  ***Indirect measures of economic costs of many water-quality effects must be estimated using statistical analyses to measure the implicit loss in value of impaired fishing, swimming, and other recreation opportunities. These data are collected by surveying individuals about the value they place on the existence of environmental services provided by water resources.***

# Agricultural Production Can Have Many Off-Farm Effects on Environmental Quality

**Environmental effects arising from commercial agriculture can extend far beyond the physical boundaries of the farm.**

After plant uptake of the agricultural chemicals applied to cropland, some residues may remain in the soil, move to the atmosphere, or enter waterways through cropland runoff. These residues and their breakdown products in the air and streams can have adverse ecological effects far from the point where they are applied to cropland.

## Some Cropland Has Greater Potential for Water-Quality Problems Than Other Cropland

The potential for fertilizers and pesticides to accumulate in ground water depends on a combination of factors. Soil characteristics, geologic factors, and rainfall all influence the likelihood that chemicals applied to cropland will leach into ground water or be washed away into lakes and streams. Areas most at risk for ground water contamination generally have sandy, highly permeable soils with little organic matter, receive enough rainfall or irrigation to promote deep leaching, and are located over shallow, unconfined aquifers. The seriousness of any nonpoint source surface water pollution from cropland runoff also depends on soil type, type of tillage practices, and intensity of agricultural chemical use. Some cropping patterns, such as growing corn on the same land year after year, are more erosive and use more farm chemicals than others and have a greater potential for runoff to degrade the quality of adjacent waters (fig. 1).

The potential for chemicals and sediment to reach either surface water or ground water is also strongly influenced by fertilizer and pesticide use, method and rate of applications, chemical properties of materials applied (such as solubility in water), tendency of applied chemicals to adsorb onto soil particles, and management practices used on the farm. Some chemicals may persist in the soil after application or break down into components that percolate through the soil profile into ground water. Production systems using these chemicals have a greater effect on water quality than do those using shorter lived or nonleachable chemicals.

Water-quality problems have also been caused by manure accumulations and disposal. When manure is spread on frozen fields or when plants do not need nitrogen, excess nitrogen can leach to ground water or run off to surface water. Runoff from feedlots and areas of intensive livestock production can create point sources of nutrient pollution of both surface and ground water.

## Surface Water and Ground Water Quality Are Related

Underground aquifers may discharge into lakes and streams, causing degraded ground water to contribute to surface water pollution. Also, chemicals dissolved in surface water runoff may enter ground water through abandoned mines and wells, or sinkholes in karst areas.

## Impaired Water Quality Affects Humans, Livestock, and Wildlife

When runoff from cropland reaches lakes, streams, and estuaries, residues from nutrient or pesticide applications and sediments can contribute to water-quality problems. Nutrients, particularly nitrogen and phosphorus, promote algae growth and premature aging of lakes, streams, and estuaries (a process called eutrophication). Sediment harms aquatic life by reducing sunlight, smothering spawning grounds, and choking fish. Pesticide residues reaching surface water systems may also harm freshwater and marine organisms.

The primary concern with agricultural chemicals in ground water is the possibility that exposure to dissolved materials in drinking water may pose a human health risk. A well-documented human health risk from nitrate contamination is infant methemoglobinemia, by which nitrates impair the ability of an infant's blood to carry oxygen (USDA, 1991). Other agricultural chemicals may also pose health risks when present in drinking water, but the amount of risk posed to humans is uncertain (Conservation Foundation, 1987). Concentration of pesticides or nitrates in drinking water may be below levels at which acute health effects have been observed. The health risk associated with ingesting water containing traces of pesticides or nitrates at levels below those in which human health is considered endangered is poorly understood (Conservation Foundation, 1987).

## Wetlands Provide Many Environmental Services That Agricultural Production Can Impair or Destroy

Quality of water in wetlands can also be degraded from excessive levels of contamination by farm chemicals and runoff. Wetlands are also directly destroyed when drained for crop production. Water degradation and wetland loss reduce direct and indirect environmental benefits of wetlands. Wetlands provide direct benefits through the fish, wildlife, and plant life they support. Indirect benefits of wetlands flow from their water-cleaning capability, flood control, and their support of fisheries in lakes, streams, or estuaries.

Wetlands directly provide many social benefits. These benefits are accentuated by wetlands' unique habitats that support bird, fish, and plant species that otherwise may not exist. Wetlands provide food, cover, and nesting for a wide variety of plants and animals, and provide spawning grounds and juvenile habitat for many important fish populations that have both recreational use and commercial value. Wetlands can also support tree growth for commercial harvest, flood control, and shoreline stabilization.

Figure 1

**Conflicts between agriculture and water quality**

*Chemical runoff, soil erosion, leaching of nitrates, and draining of wetlands are all consequences of agricultural production.*

**Agricultural land**

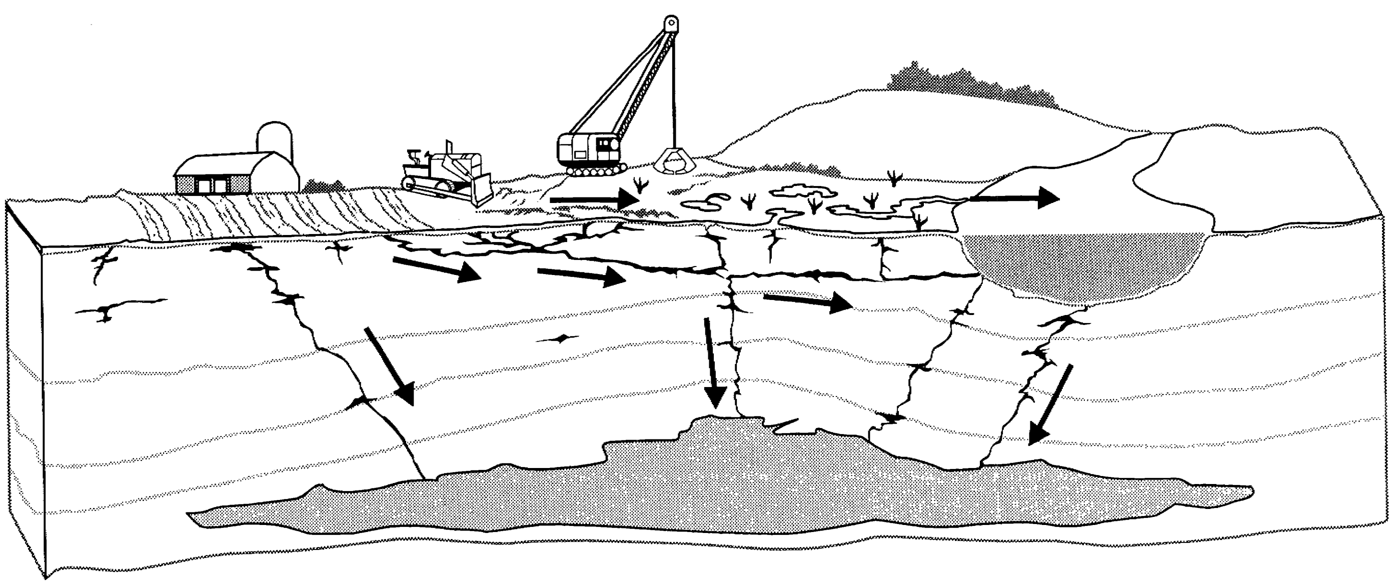
Chemicals applied to crops may not be fully used by plants, leaving residuals in the soil. Chemicals may break down over time and be carried to wetlands, lakes, and streams by runoff, or leach to ground water.

**Wetlands**

Wetlands have a valuable ecological role, providing wildlife habitat and protecting lakes and streams from runoff by filtering out some pollutants. These services are lost if wetlands are drained to grow crops.

**Surface water**

Lakes and streams may be affected by nutrients, sediments, or pesticides in runoff from agricultural land or irrigation return flows. Lakes and streams also may be affected by agricultural chemicals in return flows from ground water.



**Underground aquifers**

Vulnerability of ground water resources to contamination from pesticides and nutrients depends on many factors, including types of chemicals applied, depth of the aquifer, and characteristics of the overlying soil and rock formations.

# Pesticide and Fertilizer Use on U.S. Farms Has Increased Over the Past 30 Years, While Many Areas of Wetlands Have Been Converted to Crop Production

**Economic and agricultural policy factors have encouraged intensive use of agricultural chemicals and subsidized wetland drainage for agriculture.**

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U.S. agriculture increasingly relies on chemical fertilizers, herbicides, insecticides, and fungicides. Use of inorganic nitrogen fertilizers (a source of nitrate in ground water) increased by a factor of four during 1960-80. Nitrogen application rates on corn and wheat more than doubled between 1964 and 1985 (fig. 2). Use of pesticides on cropland rose from an estimated 225 million pounds active ingredient (a.i.) in 1964 to nearly 560 million pounds a.i. by 1982. Herbicides are used most intensively on corn and soybeans, while application rates of insecticides are greatest in grain production (fig. 2). Recent trends in both nitrogen fertilizer and pesticide use have been downward; application of pesticides fell to 480 million pounds by 1991. This decline reflects both the depressed farm economy in the early part of the 1980's and shifts to chemicals that are applied at lower rates than those previously used (Osteen and Szmedra, 1987).

Agricultural chemical use grew during the past 30 years because the costs of chemicals fell relative to other farm inputs, such as labor, fuel, and machinery. Since chemicals were cheaper, they were substituted for other inputs. Use of pesticides and inorganic fertilizers may have been encouraged by farm commodity programs, which increase the relative return to input-intensive crops and discourage chemical-reducing crop rotations.

## New Survey Data Indicate Widespread Herbicide Use

USDA has begun a new data collection program to gather detailed statistics on agricultural chemical use. Herbicides are the most widely used pesticide, accounting for about 84 percent of total pounds of pesticides applied. Survey results for 1990 and 1991 show that more than 90 percent of the acreage devoted to corn, soybeans, sorghum, cotton, and spring and durum wheat were treated at least once with herbicides. Insecticides were used on 14 percent of the acreage, and fungicides on only 2 percent. Corn, cotton, and soybeans together account for most pesticide use, about 87 percent of herbicides, and 86 percent of insecticides (USDA, 1991).

## Farm Policy Decisions Can Influence Potential for Chemical Leaching and Runoff

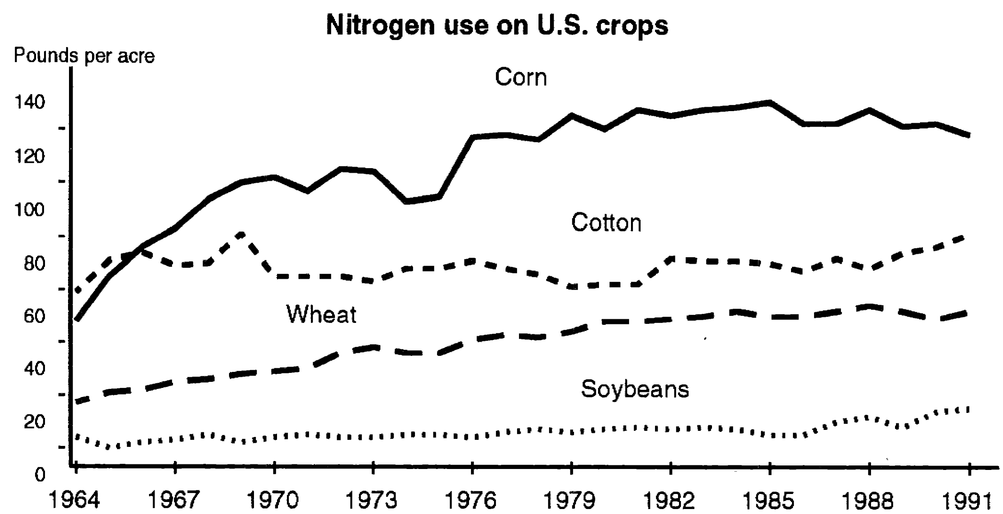
Federal agricultural programs, such as price supports, base acreage requirements, or subsidies for irrigation, may encourage production of crops that can have unintended off-farm environmental effects (Crutchfield, 1990; Reichelderfer and Phipps, 1988). For example, base acreage requirements and corn price supports may have encouraged some farmers to grow corn on the same land year after year, which tends to be erosive, and to use large amounts of chemicals. A more flexible policy would allow farmers to rotate crops, thus reducing adverse effects on water quality. Prior to the 1990 farm legislation, agricultural policies discouraged crop rotations because changing crops may have resulted in a loss of crop base upon which program payments are based. Federal subsidies for irrigation water can lead to increased irrigation, thereby affecting quality by increasing the concentration of pesticides and nitrogen in irrigation water return flows.

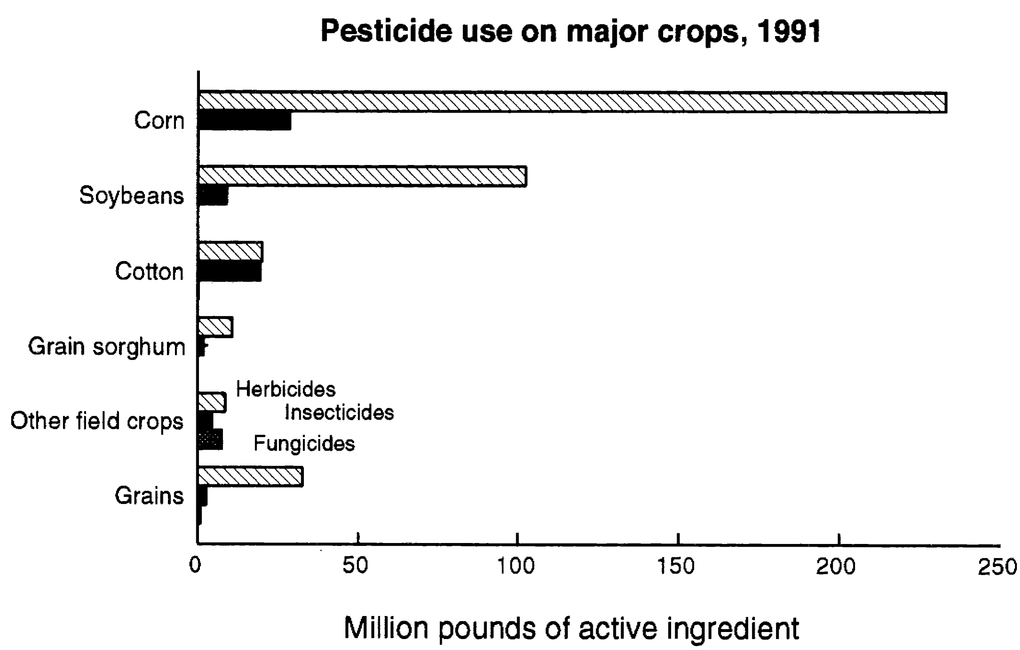
## Early Wetland Policy Encouraged Drainage of Wetlands

Over half of the 221 million acres of wetlands in the United States were drained between 1780 and 1980. Federal incentives to drain wetlands existed until the early 1970's. Most of the drained areas were converted to agricultural use. The "Swampbuster" provision of the Food Security Act of 1985 denies a wide range of farm program benefits to farmers who drain wetlands. The provision has reduced, though not eliminated, wetland losses. Annual losses were estimated at 124,000 acres between 1982 and 1987, the most recent estimates available (Heimlich, 1991).

Figure 2

## Agricultural chemical use in the United States




Source: USDA, 1992.

# Some of America's Ground Water May Be Vulnerable to Agricultural Chemical Leaching

**Potential risk to underground water sources depends on how, when, and where chemicals are used.**

Studies of ground water vulnerability at the national level have combined estimates of physical characteristics of cropland with estimates of agricultural chemical use and available water-quality monitoring data. Using this approach, Nielsen and Lee (1987) and Kellogg, Maizel, and Goss (1993) identified areas where hydrogeologic conditions appear to favor movement of water to aquifers and where agricultural practices using large amounts of leachable pesticides and nitrogen fertilizer are found (fig. 3).

## Ground Water Vulnerability to Chemical Leaching Depends on Many Factors

The potential for agricultural chemicals to accumulate in ground water depends on a combination of environmental factors and farm management decisions. Irrigation practices, kinds and quantities of chemicals used, and chemical properties of pesticides influence the likelihood of chemicals being leached into ground water, in addition to the influence of the soil and geophysical characteristics of cropland overlying ground water.

Areas most at risk for chemicals leaching into ground water generally have sandy, highly permeable soils, receive enough rainfall or irrigation to promote leaching, and are located over shallow, unconfined aquifers. The potential for agricultural chemicals to leach into ground water is also influenced by properties of the materials applied (such as water solubility or the tendency to attach to soil particles) and how the chemicals are used (for example, method, timing, and rate of application).

## Potential for Nitrate or Pesticide Contamination Varies by Region

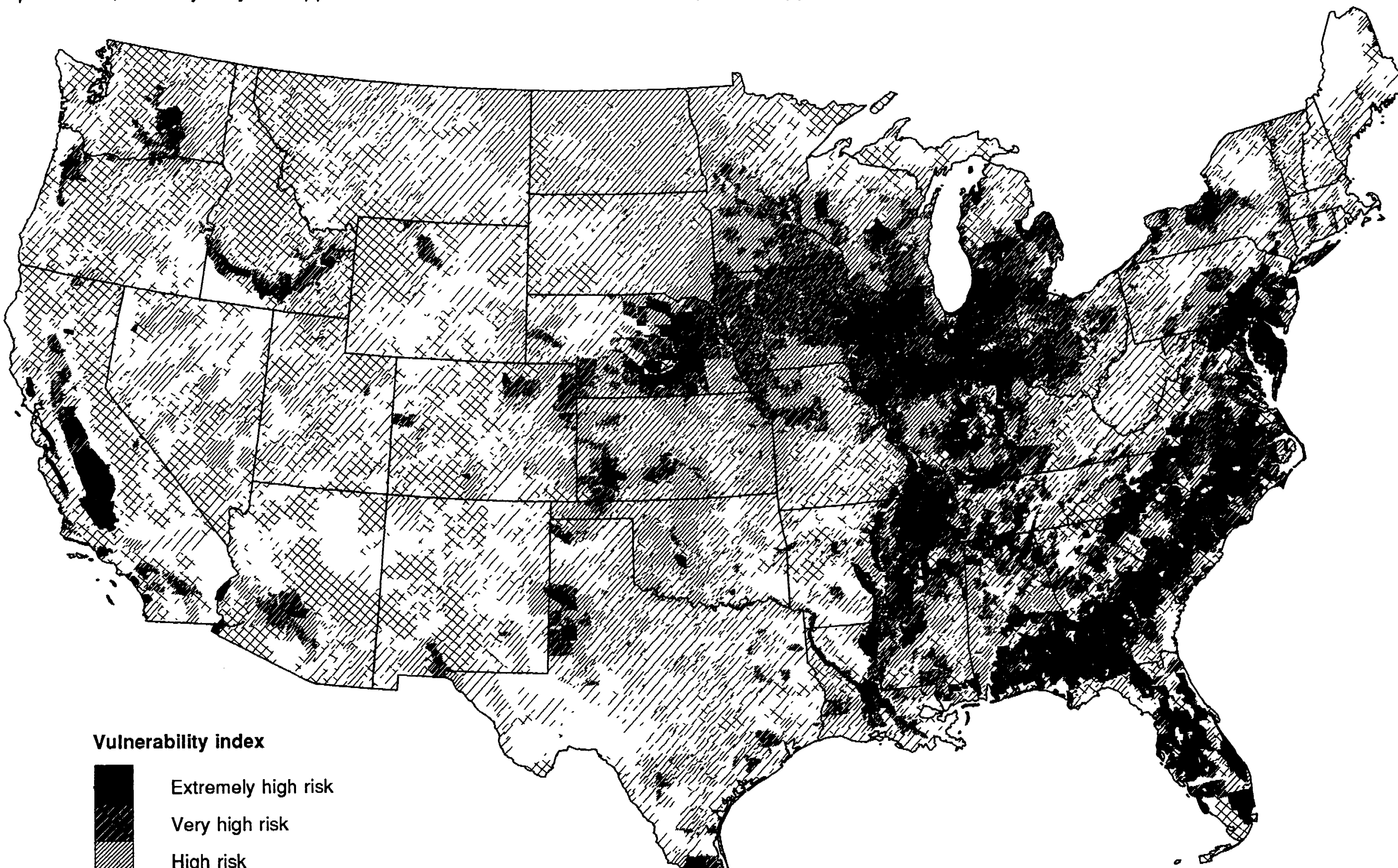
The ground water of some regions is more vulnerable to pesticides than to nitrates, and vice versa. The Corn Belt, Southeast, and Lake States have more acreage thought to be both vulnerable to leaching and treated with leachable pesticides. Conversely, the Northern and Southern Plains regions show more acreage with a potential for nitrate leaching than for pesticide leaching. This variability among regions illustrates the importance of targeting ground water protection strategies.

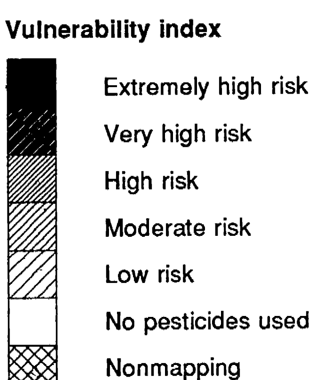
Vulnerability does not necessarily indicate contamination. Aquifers considered vulnerable to chemical leaching may not be contaminated. The time factor must be kept in mind. Even if a given aquifer is found to be free from chemical residues, it may take years for a "plume" of chemicals applied to cropland to leach through overlying soil into aquifers. There is considerable variability in any measure designed to quantify vulnerability of ground water to chemicals applied to overlying cropland; these assessments will unavoidably mask some localized variability in vulnerability arising from specific local hydrogeologic conditions.

Figure 3

## Ground water pesticide vulnerability in the United States, 1993

*The potential for pesticides to leach into underground water resources depends on the chemical properties of the pesticides, the way they are applied, and the soil characteristics at the point of application.*






This map was prepared through a cooperative project involving the U.S. Department of Agriculture's Soil Conservation Service and Economic Research Service, and the National Center for Resource Innovations.

Sources: 1982 National Resource Inventory/SOILS-5 Databases, SCS/USDA; Soils Pesticide Potentials, D. Goss, SCS/USDA; Percolation Factor, Williams and Goss; and Pesticide Use, Resources for the Future, July 1992.

# Pesticides and Nitrates From Fertilizer May Pose a Risk to Some Drinking Water Supplies

**Drinking water supplies in some rural areas may be vulnerable to leaching pesticides and fertilizers.**

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## EPA Data Show National Extent of Agricultural Chemicals in Drinking Water

The Environmental Protection Agency has released results of a nationwide survey of drinking water wells. Conducted over a 5-year period, the survey evaluated the presence of pesticides and nitrates in both community and private drinking water wells. The survey showed that while at least half of the Nation's drinking water wells contained detectable amounts of nitrate, only about 1.2 percent of community water systems and 2.4 percent of rural private domestic wells contained nitrates at levels higher than EPA's recommended levels (fig. 4). About 10 percent of community wells and 4 percent of domestic wells contained detectable levels of one or more pesticides, but EPA estimates that less than 1 percent of the wells contained pesticides at concentrations higher than those considered to pose an unacceptable risk to human health.

The EPA survey, however, does not fully reflect the overall scope of potential ground water quality problems related to agricultural chemicals. The survey collected data on drinking water at the tap, and was not designed to accurately characterize the quality of the Nation's underground water systems. The U.S. Geological Survey is studying the quality of America's ground water resources in a comprehensive manner in its National Water Quality Assessment, but this project will not be complete for several years.

## Not All Instances of Ground Water Contamination Are Due to Normal, Recommended Chemical Use

In addition to field use of pesticides, local chemical contamination can also arise from spills, careless mixing and rinsing, improper disposal of chemical containers, back-siphoning into irrigation wells, septic tank drainage, and land disposal of municipal and industrial wastes. High nitrate concentrations in ground water can arise from a variety of agricultural and nonagricultural activities. Primary agricultural sources of nitrogen include fertilizer use, feedlots, dairy and poultry farming, and cultivation of mineralized soils. Nonagricultural sources, such as natural deposits of nitrate-bearing minerals, septic tanks, and municipal wastes may also contribute to occurrences of nitrates in ground water.

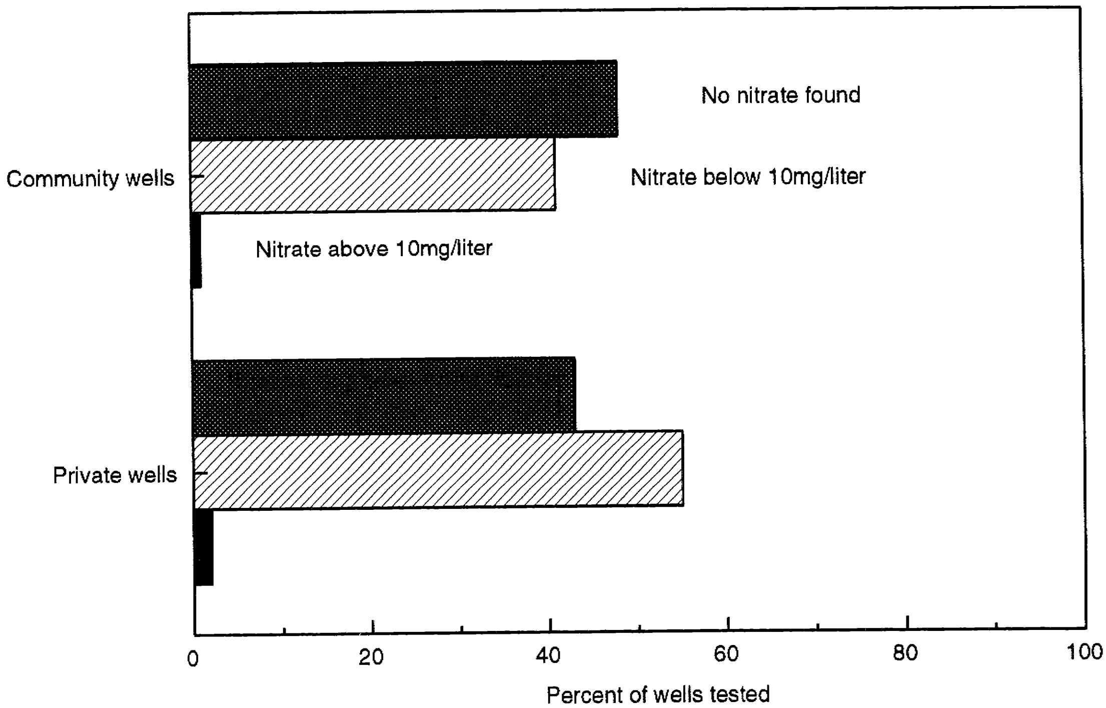
## Avoiding Exposure to Contaminated Drinking Water May Involve Costly Monitoring

ERS has analyzed some costs incurred by consumers to avoid consuming drinking water that may contain agricultural chemicals. A "damage avoided" approach measures costs society would have to pay to reduce the risk of exposure by estimating the costs of monitoring private and public wells for the presence of pesticides and nitrates. Testing private drinking water wells in areas thought to be potentially vulnerable for the presence of nitrates or pesticides on a one-time basis is estimated to cost between $890 million and $2.2 billion. Monitoring costs for public wells may be much smaller (about $14 million per year) than those for private wells because there are many more private wells than public, and each public well serves many people (Nielsen and Lee, 1987).

Figure 4

## Agricultural chemicals in U.S. drinking water wells, 1990

*Detection of agricultural chemicals in ground water has caused concern, but extent and seriousness of any potential pesticide or nitrate contamination are still uncertain.*




Source: EPA 1990

### Uncertainties Remain About the Seriousness of Ground Water Pollution

- Detection of chemicals does not necessarily mean the ground water is unsafe to drink; some of the reported detections are at concentration levels well below EPA health standards.

- As yet, no comprehensive, nationwide data exist on the extent to which pesticides and nitrates are present in the Nation's ground water. The EPA survey provides a snapshot of drinking water quality, but does not accurately characterize the quality of the aquifer.

- Presence or absence of chemicals from any well may not indicate future water quality since it may take months or even years for chemicals applied to cropland to leach into ground water.

# Agricultural Runoff and Wetland Conversion Affect the Quality of Lakes, Streams, and Estuaries

**Sediment, fertilizers, and pesticides from cropland runoff are sources of surface water quality problems, but effects vary across the Nation.**

Soil erosion and runoff from agricultural land can carry nutrients and dissolved solids to surface water bodies. Nationwide, runoff from agricultural land contributes nearly 60 percent of the sediment and about half of the phosphorus and nitrogen reaching freshwater systems. The Economic Research Service studied the extent of agricultural nonpoint source pollution in America's streams and lakes (Ribaudo, 1986). Using data on sources and levels of surface water pollution from the Environmental Protection Agency and Resources for the Future, the relative contribution of agricultural sources to the overall water-quality problem was identified (Gianessi, Peskin, and Puffer, 1985). Of the 99 watersheds examined in the ERS study, 48 had levels of sediment high enough to impair use, 28 had undesirable levels of nitrogen, and 60 were impaired by phosphorus. The study found runoff from agricultural land (including cropland, rangeland, and forest land) to be a "significant source" (defined as contributing more than 50 percent of pollutant discharge) of nitrogen in nine watersheds. Agricultural sources of sediment were significant in 34 watersheds, and 31 watersheds had significant agricultural discharge of phosphorus (fig. 5).

## Agricultural Runoff a Problem for Some Coastal Water Bodies

Soil erosion and runoff from cropland also contribute to water-quality problems in coastal areas. ERS studies have obtained data from the EPA and the National Oceanic and Atmospheric Administration on quantities (loadings) of surface water pollutants from both point and nonpoint sources in 22 coastal States and 78 estuarine systems. Among specific pollutants the study identified were nutrients, sediment, and pesticides. For the 78 estuarine systems considered, agricultural runoff supplied an average of 24 percent of total nutrient loadings and 40 percent of total sediment. Agriculture contributed more than 25 percent of the total nutrients in 22 of the 78 estuaries. High rates of pesticide losses to surface waters were found in 21 systems. Fifteen estuarine systems showed both significant agricultural nutrient loadings and high pesticide losses (Crutchfield, 1987).

## Other Factors Contribute to Water-Quality Problems

Agricultural runoff and soil erosion from cropland are only two of a number of sources of water pollution. Others include urban runoff, municipal waste treatment plants, and industrial sources. Given this variety of possible sources and pathways, it can be difficult to determine whether nitrogen, phosphorus, sediment, or pesticides detected in water bodies result from agricultural or nonagricultural activities (especially when these activities coincide geographically).

## Loss of Wetlands Can Contribute to Water-Quality Problems

Wetlands are not closed aquatic systems. Most water leaves wetlands for lakes, streams, estuaries, or aquifers. Wetlands improve water quality as suspended solids fall or are filtered out, and chemicals are absorbed or decompose. Municipalities have created artificial wetlands to assist their wastewater purification processes since such lands are so effective at removing impurities. Aquifers receiving water from wetlands gain benefits from both the water's quality and quantity: water-quality benefits through the adsorption and decomposition of nutrients and other chemicals, and water-quantity benefits by recharging the aquifer.

## Impaired Quality of Surface Water Also Has Economic Cost

Several studies have estimated costs of agricultural nonpoint source pollution of surface water. One study estimates costs of impaired water quality from cropland erosion to be $2-$8 billion per year, with a "best guess" estimate of $3 billion per year. These annual costs consist primarily of damage to freshwater fishing, boating, and recreation (28 percent), water storage facilities (13 percent), navigable waterways (as silt requires dredging), commercial fishing, and municipal treatment plants (Ribaudo, 1987).

Figure 5

## Surface water pollution from agricultural sources

*The effects of chemical runoff and soil erosion on lakes, streams, and estuaries vary across the Nation.*

**Agricultural sources of coastal and estuarine pollution**

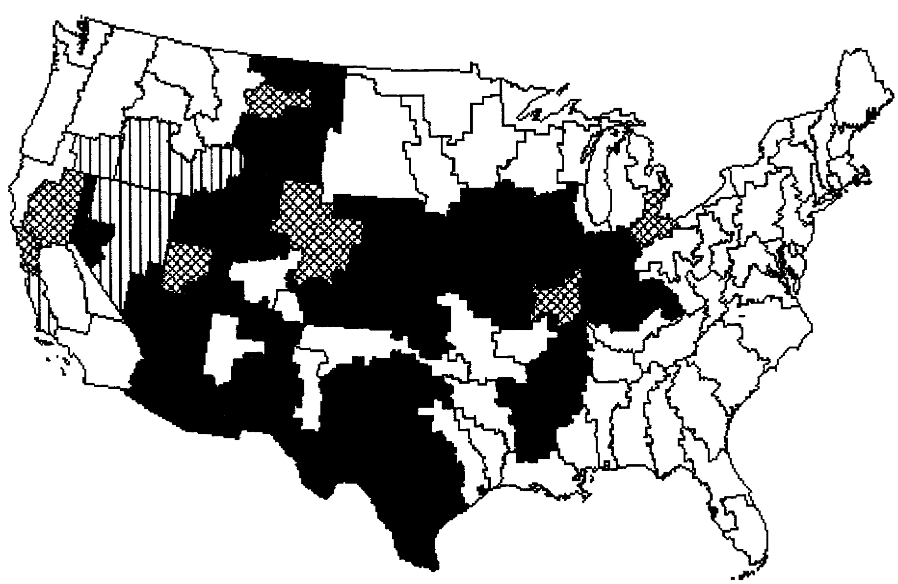
- Agricultural sources account for more than 25 percent of total phosphorus and nitrogen.
- Regions with higher than average pesticide runoff from cropland.
- Both high pesticide runoff and significant nutrient runoff from cropland.
- Agriculture is not a significant source of pollution.

Source: Crutchfield, 1987.

**Agricultural sources of freshwater pollution**

- Agriculture supplies more than 50 percent of nutrient loadings.
- Agriculture supplies more than 50 percent of sediment loadings.
- Agriculture supplies more than 50 percent of both nutrient and sediment loadings.

Source: Ribaudo, 1986.



### Pollution comes from many sources

**Pesticides**-may damage valuable marine fishery resources and contaminate drinking water supplies.

**Nutrients**-may degrade water quality when nitrogen and phosphorus promote algae growth, harm aquatic organisms, and impair recreational uses.

**Sediments**-may clog waterways, increase water treatment costs, and carry attached nutrients.

**Point sources**-may predominate in water systems where municipal and industrial sources of pollution contribute more pollutants to surface waters than agriculture.

# Policy Options Are Being Considered To Promote Both Environmental Quality and Profitable Agriculture

**New initiatives to control agricultural nonpoint source pollution stress preventing ground water contamination from agricultural chemicals.**

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In response to increased public awareness and concern about water-quality problems related to agriculture, Federal, State, and local officials are developing new policies and programs to address the issue. New research and demonstration initiatives are being implemented by USDA and other Federal agencies. In addition, several existing programs (such as USDA soil conservation efforts) are being reoriented and refocused to stress off-farm water-quality concerns as well as more traditional onfarm soil productivity issues.

Past efforts to reduce pollution have taken a regulatory approach, in which the Government sets standards for allowable discharges to air and water, and imposes fines and penalties when these standards are exceeded by polluters. A less rigid approach is generally considered preferable in the case of agriculture. Since agricultural sources of pollution can be diffuse and difficult to monitor, it is often impossible to establish environmental consequences of an individual farmer's actions. Rather than directly regulate each farmer, public policy to prevent agricultural pollution generally relies on a combination of incentives and technical assistance to encourage adoption of less-polluting farm management systems, with some regulations on chemical application and handling to protect against improper or dangerous use.

## USDA's Water Quality Program and Other Federal Policies Stress Voluntary Approaches to Protecting Water Quality

The USDA Water Quality Program is a multiagency program to assess water-quality problems and to develop means to prevent or reduce degradation of the Nation's surface and ground water resources (see box, facing page). USDA and other Federal agencies provide farmers, ranchers, and foresters with information, education, and technical and financial assistance to address onfarm environmental concerns and State water-quality requirements.

A principal emphasis of the program is ground water protection, particularly protection from nitrogen fertilizer, pesticides, and animal waste. Since water-quality problems related to the use of agricultural chemicals tend to be localized, national policies and programs stress the importance of joint, cooperative efforts with State and local governments. Federal activities in support of the initiative fall into three components: research and development, data and evaluation, and education and technical assistance.

EPA policy in implementing the 1987 Water Quality Act (WQA) and the agricultural chemicals in ground water strategy also emphasizes the primary role of State and local officials in the design and implementation of pollution control and mitigation. Federal agencies will provide technical expertise, information, and guidance to State and local officials to support nonpoint source pollution control efforts.

## Federal Farm Legislation Provides Incentives for Voluntary Adoption of Alternative Production Systems

Two programs established by 1990 farm legislation provide cost sharing and other financial assistance to farmers to encourage environmentally sound farming practices and to protect water quality. Farmers may enroll land in a Water Quality Incentive Project. This program is targeted to lands considered environmentally sensitive, such as priority watersheds identified in State reports filed with EPA as required under Section 319 of the 1987 WQA, sinkholes, wellhead protection areas, and habitat for endangered species. Farmers in targeted areas will be eligible for annual payments up to $3,500 in Agricultural Conservation Program payments as an incentive to implement water-quality management plans lasting 3-5 years that are approved by USDA. In addition, USDA will assist farmers to develop and implement water-quality protection plans. This technical assistance program emphasizes farm-level strategies in areas identified by State and Federal officials as having agricultural nonpoint source pollution impairments.

The Conservation Reserve Program (CRP) has been redirected under the new law. Up to 11 million additional acres could be enrolled in the CRP in areas not previously eligible, since several new categories of environmentally sensitive lands are defined in addition to "highly erodible" land. Lands thought to endanger water quality when used for agricultural production may now be eligible for CRP retirement even if they do not meet the previous enrollment criterion of highly erodible.

The 1990 farm legislation makes a number of changes to program rules to encourage planting flexibility. Increased flexibility is expected to lead to reduced intensity of agricultural chemical use, reduced soil erosion, and an associated benefit in terms of water-quality protection. If farmers are free to rotate their crops instead of planting one crop year after year to protect program base, then they may be able to break pest cycles and reduce pesticide use. Similarly, reliance on chemical fertilizers may be reduced, which could help protect both ground and surface waters from nitrogen pollution. The Integrated Crop Management Program (ICM) is being tried in some counties to reduce agricultural chemical use. Farmers receive incentive payments for using integrated pest management, new rotations, and other steps for more efficiently using chemicals.

### Concept of Acreage Reserve Is Extended to Wetlands

The 1990 farm legislation also created a new "Wetland Reserve Program" (WRP). USDA plans to enroll between 600,000 and 1 million acres in the program, modeled after the Conservation Reserve Program, to restore wetlands that were converted to agricultural uses before 1985. Participants will receive annual payments, including cost sharing for restoration costs. Easements contracts will be long term, rather than 10-year contracts as in the CRP. Easements may run for 30 years, on a permanent basis, or for the maximum duration under State law. USDA will also prepare guidelines and maps for wetland delineation and determination of program eligibility under the "Swampbuster" provisions. Exact determination of what constitutes a wetland for these programs is still under debate.

### Success of Voluntary Programs Depends on Financial Appeal of Alternative Production Systems

To assure wide-scale adoption of best management practices, voluntary programs must offer economic benefits to those adopting them. Some form of cost sharing or financial assistance may be necessary to speed adoption. Expenditure of public monies to assist farmers in adopting new farming practices may be justified on the basis of the benefits received by the general public as off-farm water quality is protected and enhanced.

Making both penalties (such as forfeiture of USDA program benefits under conservation compliance) and incentives (subsidies) relating to water quality responsive to market conditions may be useful components of programs and policies to protect water quality. This would help ensure that these incentives point in the right direction. It is vital that any programs or policies directed at water quality account for interactions with other agricultural policies, and that environmental programs are consistent with commodity programs and provide appropriate economic incentives for farmers to voluntarily adopt environmentally sound production practices.

### New Environmental Quality Legislation and Policy Initiatives

*New legislation and policies stress voluntary approaches to preventing pollution.*

#### New water-quality policies in 1990 farm legislation

- Expansion of the Conservation Reserve Program: Expand eligibility to include lands that, while not highly erodible, lie over vulnerable ground water resources, and lands where agriculture contributes to water-quality problems.
- Incentives to enroll lands in 3- to 5-year contracts to adopt new farming practices to protect water quality.
- Increased planting flexibility to encourage rotations and lower agricultural chemical use.
- Increased efforts to provide education and technical assistance in support of environmentally sensitive farming practices, low-input agriculture, and integrated crop management.
- Creation of a "Wetlands Reserve Program" (WRP). New wetlands delineation maps and certifications of wetland determinations for program benefit eligibility under "Swampbuster" provisions.

#### The USDA Water-Quality Program (Joint Effort by U.S. Department of Agriculture, Environmental Protection Agency, U.S. Geological Survey, and National Oceanic and Atmospheric Administration)

- Research and development of new farming systems.
- Education, technical, and financial assistance to promote voluntary adoption of new technologies and practices.
- Agricultural chemical use and practices surveys.

## References


Conservation Foundation. *Groundwater Protection.* Washington, DC, 1987.

Crutchfield, Stephen R. "Controlling Farm Pollution of Coastal Waters." *Agricultural Outlook*, AO-136, Nov. 1987, 24-25.

Crutchfield, Stephen R. "Nonpoint Pollution, Water Quality, and Commodity Programs in the 1990 Farm Bill." *Journal of Agribusiness*, Vol. 8, No. 1, Spring 1990, 33-52.

Gianessi, Leonard, Henry Peskin, and Cynthia Puffer. *A National Data Base of Nonurban Nonpoint Source Discharges and their Effect on the Nation's Water Quality.* Resources for the Future, 1985.

Goolsby, Don A., R.C. Coupe, and D.J. Markovchick. "Distribution of Selected Herbicides and Nitrates in the Mississippi River and its Major Tributaries, April through June 1991." *U.S. Geological Survey Water-Resources Investigations Report 91-4163*, 1991.

Heimlich, Ralph. "New Wetland Definition Debated." *Agricultural Outlook*, AO-152, Nov. 1991, 22-24.

Kellogg, Robert, Margaret Maizel, and Donald Goss. "Agricultural Chemical Use and the Potential for Ground Water Contamination: How Big Is the Problem?" U.S. Dept. Agr., Econ. Res. Serv., Soil Cons. Serv., Coop. State Res. Serv., and National Center for Resource Innovations, 1993.

Nielsen, Elizabeth G., and Linda K. Lee. *The Magnitude and Costs of Groundwater Contamination from Agricultural Chemicals.* AER-576, U.S. Dept. Agr., Econ. Res. Serv., Oct. 1987.

Osteen, Craig D., and Philip I. Szmedra. *Agricultural Pesticide Use Trends and Policy Issues.* AER-622, U.S. Dept. Agr., Econ. Res. Serv., Oct. 1987.

Reichelderfer, Katherine, and Tim Phipps. "Agricultural Policy and Environmental Quality." National Center for Food and Agricultural Policy, Resources for the Future, Nov. 1988.

Ribaudo, Marc O. "Agriculture's Impact on Water Quality." *Agricultural Resources: Cropland, Water, and Conservation Situation And Outlook Report*, AR-8, U.S. Dept. Agr., Econ. Res. Serv., Sept. 1987, 30-32.

Ribaudo, Marc O. "Targeting Soil Conservation Programs." *Land Economics*, Vol. 82, No. 4, Nov. 1986, 402-411.

U.S. Department of Agriculture, National Agricultural Statistics Service and Economic Research Service. *Agricultural Chemical Usage 1991: Field Crops Survey.* Ag. Ch. 1, Mar. 1992.

U.S. Department of Agriculture, Working Group on Water Quality. "Nitrate Occurrence in U.S. Waters (and Related Questions)." Sept. 1991.

U.S. Environmental Protection Agency. *National Water Quality Inventory: 1990 Report to Congress.* EPA 503-9-92-006, Washington, DC, Apr. 1992.

U.S. Environmental Protection Agency. *National Pesticide Survey Phase 1 Report.* Washington, DC, EPA 570/9-90-003, Sept. 1990.

Williams, W. Martin, Patrick W. Holden, Douglas W. Parsons, and Matthew N. Lorber. *Pesticides in Ground Water Database - 1988 Interim Report.* U.S. Environmental Protection Agency, Dec. 1988.

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