2.2 Water Quality

Agricultural production often emits pollutants that affect the quality of the Nation's water resources and impose costs on water users. The extent and magnitude of agricultural pollution is difficult to assess because of its nonpoint nature. However, agriculture is the leading source of impairment in the Nation's rivers and lakes, and a major source of impairment to estuaries.

Contents

Producing food and fiber involves many activities and practices that can affect the quality of water resources under and near the field. For example, tilling the soil and leaving it without plant cover for extended periods of time results in accelerated soil erosion. The use of chemical inputs increases the probability that some of these materials will wash off or leach through the field to enter water resources. Irrigation can move salt and other dissolved minerals to surface water. Livestock operations produce large amounts of waste which, if not properly disposed of, can threaten human health as well as contribute to excess nutrient problems in streams, rivers, and lakes.

Quality of the Nation's Water

The Clean Water Act (passed in 1972 as the Federal Water Pollution Control Act) defines water quality in terms of designated beneficial uses with numeric and narrative criteria that support each use. Designated beneficial uses are the desirable uses that water resources should support. Examples are drinking water supply, primary contact recreations, and aquatic life support. Numeric water quality criteria establish the minimum physical, chemical, and biological parameters required for water to support a beneficial use. Physical and chemical criteria may set maximum concentrations of pollutants, acceptable ranges of physical parameters, and minimum concentrations of desirable parameters, such as dissolved oxygen. Biological criteria describe the expected attainable community attributes and establish values based on measures such as species richness, presence or absence of indicator taxa, and distribution of classes of organisms (EPA, 1994). Narrative water quality criteria define conditions and attainable goals that must be maintained to support a designated use. Narrative biological criteria describe aquatic community characteristics expected to occur within a water body.

Surface-Water Quality

The Nation's surface-water quality has improved since 1972, primarily through reductions in pollution from point sources. However, many water quality problems remain. Water Quality Inventories, published by the U.S. Environmental Protection Agency (EPA), show no major improvement in the quality of the Nation's rivers, lakes, ponds, and estuaries since 1990 (EPA, 1995). Agriculture is cited by States as a leading source of water quality impairment. A little over one-third of river miles, lake acres (excluding the Great Lakes), and estuarine waters assessed by the States were found to not fully support their designated uses in 1994 (table 2.2.1).

The Great Lakes continue to suffer serious pollution, even though some progress has been made in reducing the worst cases of nutrient enrichment

Table 2.2.1—Status of the Nation's surface-water quality, 1988-94

Item	Rivers				Lakes[1]				Estuaries			
	1988	1990	1992	1994	1988	1990	1992	1994	1988	1990	1992	1994
	Percent of total water											
Water systems assessed	29	36	18	17	41	47	46	42	72	75	74	78
	Percent of assessed waters											
Meeting designated uses:												
Supporting	70	69	62	64	74	60	56	63	89	67	68	63
Partially supporting	20	21	25	22	17	19	35	28	8	25	23	27
Not supporting	10	10	13	14	10	21	9	9	3	8	9	9
Clean Water Act goal of fishable:												
Meeting	86	80	66	69	95	70	69	69	97	77	78	70
Not meeting	11	19	34	31	5	30	31	31	3	23	22	30
Not attainable	3	1	-	-	-	0	-	-	0	-	0	0
Clean Water Act goal of swimmable:												
Meeting	85	75	71	77	96	82	77	81	92	88	83	85
Not meeting	11	15	20	23	4	18	22	19	1	12	17	15
Not attainable	4	10	9	-	-	-	-	-	7	-	0	-

- = less than 1 percent of assessed waters.
[1] Excluding Great Lakes.
Source: USDA, ERS, based on Environmental Protection Agency National Water Quality Inventories, 1988, 1990, 1992, 1994.

(particularly in Lake Erie). Only 3 percent of the assessed shoreline miles (with 96 percent assessed) fully support designated uses (EPA, 1995). Sixty-three percent of the assessed shoreline does not support designated uses at all. Most of the Great Lakes shoreline is polluted with toxic organic chemicals, primarily PCB's and DDT that are often found in fish samples. Atmospheric deposition of toxics, including pesticides, and contaminated sediments are the leading sources of impairment.

The Chesapeake Bay, the largest estuary in the world, has seen water quality degrade over time because of agricultural development, population growth, and sewage treatment plant emissions. While an aggressive program has reduced phosphorus, nitrogen concentrations remain high, leaving the bay overenriched. Shellfish harvests have declined dramatically in recent years, and poor water quality is believed to be an important contributing factor.

Contaminated seafood and fishkills are also indicators of surface water quality. States issue fish consumption advisories to protect the public from ingesting harmful quantities of toxic pollutants. All States but Alaska, South Dakota, and Wyoming issued fish consumption advisories in 1994, for a total of 1,531. This was up from 1,279 fish consumption advisories in 46 States in 1993 (EPA, 1994). Mercury, PCB's, chlordane, dioxin, and DDT caused more than 93 percent of the fish consumption advisories in 1994. These contaminants have been linked with human birth defects, cancer, neurological disorders, and kidney ailments. In addition, bacterial and viral contamination closed over 6,000 square miles of shellfish beds in 15 States during 1992-94. Most of the problems are from improperly treated sewage and urban runoff, but animal waste also contributes.

The number of fishkills provides some idea of pollutant impacts on aquatic life. These are most often sporadic events, rather than a chronic problem. Thirty-two States, tribes, and other jurisdictions reported 1,454 fishkill incidents during 1992-93 (EPA, 1995). Pesticides and manure/silage were identified by States as major contributors to fishkill incidents.

Groundwater Quality

Some States report on the general quality of their groundwater resources in Section 305(b) reports. Of 38 States that reported overall groundwater quality in 1992, 29 judged their goundwater quality to be good or excellent (EPA, 1994). Generally, States report that degradation of groundwater resources is a local occurrence. Agriculture was cited as a source in 44 of the 49 States that reported major sources of groundwater contamination.

An indication of agriculture's impact on groundwater quality comes from the EPA's National Survey of Pesticides in Drinking Water Wells, conducted in 1988-90. The survey provided the first national estimates of the frequency and concentrations of pesticides and nitrate in community water system wells and rural domestic drinking water wells. (Results of this survey are reported in following sections.) In summary, the proportion of wells found to contain any particular pesticide or pesticide degradate was low. However, many wells were affected by the presence of nitrate at levels exceeding EPA health guidelines.

Agricultural Pollutants

Agricultural production produces a wide variety of pollutants. These include sediment, nutrients, pesticides, salts, and pathogens. While farmers do not intend for these materials to move from the field to water resources, they often do. For example, as much as 15 percent of the nitrogen fertilizer and up to 3 percent of pesticides applied to cropland in the Mississippi River Basin makes its way into the Gulf of Mexico (Goolsby and Battaglin, 1993). States reported that agriculture is the leading remaining source of impairment in the Nation's rivers and lakes, and a major source of impairment in estuaries (EPA, 1995). An estimated 71 percent of U.S. cropland (nearly 300 million acres) is located in watersheds where the concentration of at least one of four common surface-water contaminants (nitrate, phosphorus, fecal coliform bacteria, and suspended sediment) exceeded generally accepted criteria in 1989 (Smith, Schwarz, and Alexander, 1994).

Sediment

Disturbing the soil through tillage and cultivation and leaving it without vegetative cover increases the rate of soil erosion. Dislocated soil particles can be carried in runoff water and eventually reach surface water resources, including streams, rivers, lakes, reservoirs, and wetlands. Sediment causes various damage to water resources and to water users.

Table 2.2.2—Trends in concentrations of agricultural water pollutants in surface waters, 1980-90

Water resources region	Nitrate	Phos-phorus	Suspended sediment
	Average percentage change per year		
North Atlantic	*	-1.4	-0.4
South Atlantic-Gulf	*	0.1	0.2
Great Lakes	*	-3.3	0.5
Ohio-Tennessee	*	-1.0	-1.3
Upper Mississippi	-0.4	-1.2	-1.3
Lower Mississippi	-1.6	-3.8	-1.2
Souris-Red-Rainy	*	-0.8	1.2
Missouri	*	-1.7	-0.2
Arkansas-White-Red	*	-3.1	-0.7
Texas-Gulf-Rio Grande	*	-0.9	-0.6
Colorado	*	-2.4	-0.8
Great Basin	*	-2.7	-0.2
Pacific Northwest	*	-1.7	-0.1
California	*	-1.4	-0.6

* Between -0.1 and 0.1.
Source: USDA, ERS, based on Smith, Alexander, and Lanfear, 1993.

Accelerated reservoir siltation reduces the useful life of reservoirs. Sediment can clog roadside ditches and irrigation canals, block navigation channels, and increase dredging costs. By raising stream beds and burying streamside wetlands, sediment can increase the probability and severity of floods. Suspended sediment can increase the cost of water treatment for municipal and industrial water uses. Sediment can also destroy or degrade aquatic wildlife habitat, reducing diversity and damaging commercial and recreational fisheries.

Siltation is one of the leading pollution problems in U.S. rivers and streams and among the top four problems in lakes and estuaries (EPA, 1995). Sediment damages from erosion have been estimated to be between $2 billion and $8 billion per year (Ribaudo, 1989). These include damages or costs to navigation, reservoirs, recreational fishing, water treatment, water conveyance systems, and industrial and municipal water use.

Soil conservation efforts over the past 10 years, particularly the Conservation Reserve Program and Conservation Compliance, are starting to pay off (see chapters 6.2 and 6.3). The National Resources Inventory reports that the average rate of sheet and rill erosion on cropland declined by about one-third between 1982 and 1992. In most regions of the country, the U.S. Geological Survey (USGS) found that suspended sediment concentrations trended slightly downward over the 1980's, particularly in the Ohio-Tennessee, and Upper and Lower Mississippi regions (table 2.2.2) (Smith, Alexander, and Lanfear, 1993). Areas characterized by corn and soybean production and mixed crops had the greatest downward trends.

Nutrients

Nutrients can enter water resources three ways. *Runoff* transports pollutants over the soil surface by rainwater or irrigation water that does not soak into the soil. Nutrients move from fields to surface water while dissolved in runoff water or adsorbed to eroded soil particles. *Run-in* transports chemicals directly to groundwater through sinkholes or porous or fractured bedrock. *Leaching* is the movement of pollutants through the soil by percolating rain or irrigation water. Soil organic matter content, clay content, and permeability all affect the potential for nutrients in soils to leach through the root zone.

Important nutrients from a water quality standpoint are nitrogen and phosphorus. Nitrogen, primarily found in the soil as nitrate, is easily soluble and is transported in surface runoff, in tile drainage, or with leachate. Phosphorus, primarily in the form of phosphate, is only moderately soluble and, relative to nitrate, is not very mobile in soils and ground water. However, erosion can transport considerable amounts of suspended phosphorus to surface waters.

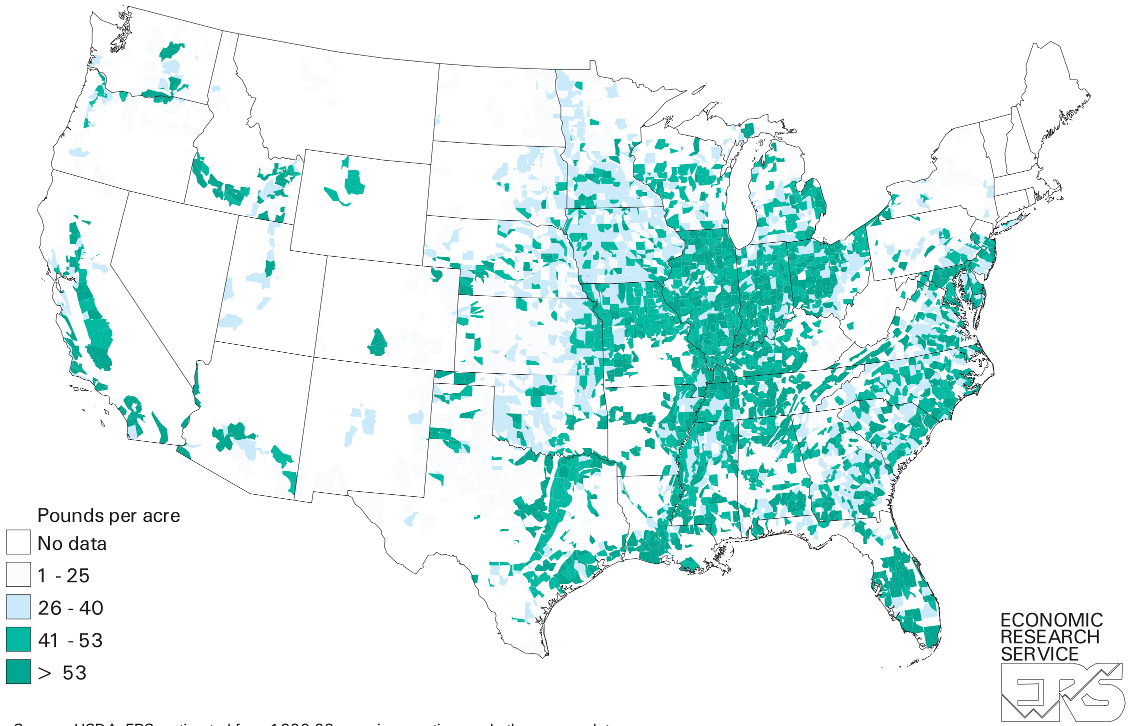
Nutrients from agriculture can accelerate algal production in receiving surface water, resulting in a variety of water-quality problems, including clogged pipelines, fishkills, and reduced recreation opportunities. Nitrate is the only nutrient for which the EPA has established a maximum contaminant level (MCL, a legal maximum long-term exposure) in drinking water (10 mg/L). Nitrate can be converted to nitrite in the gastrointestinal tract. In infants under 6 months of age, this nitrite could cause methemoglobinemia, otherwise known as "blue-baby syndrome," which prevents the transport of sufficient oxygen in the bloodstream. The presence of nitrate in concentrations above 10 mg/L in sources of public drinking water systems requires additional treatment, with associated treatment costs.

EPA reports that nutrient pollution is the leading cause of water quality impairment in lakes and estuaries, and is the third leading cause in rivers (1995). Agriculture is the primary source of nutrients in impaired surface waters.

From its 1988-90 national survey of drinking water wells, the EPA found nitrate in more than half of the 94,600 community water system (CWS) wells and almost 60 percent of the 10.5 million rural domestic wells, making nitrate the most frequently detected chemical in well water. However, only 1.2 percent of the CWS's and 2.4 percent of the rural domestic wells were estimated to contain levels above the MCL. About 3 million people (including 43,500 infants) using water from CWS's and about 1.5 million people (including 22,500 infants) using rural wells are exposed to nitrate at levels above the MCL (EPA, 1992). Higher findings for rural domestic wells are expected since they are closer to farmland and are generally shallower than wells used by CWS's, making them more susceptible to contamination. More recently, the USGS found that the MCL was exceeded in about 1 percent of CWS's, but 9 percent of rural domestic wells (Mueller and others, 1995). The difference with EPA's findings is probably due to different sampling strategies. The USGS found that about 21 percent of wells under agricultural land exceeded the MCL in selected watersheds, with particularly high proportions exceeding the MCL in the Northern Plains (35 percent) and the Pacific (27 percent) regions.

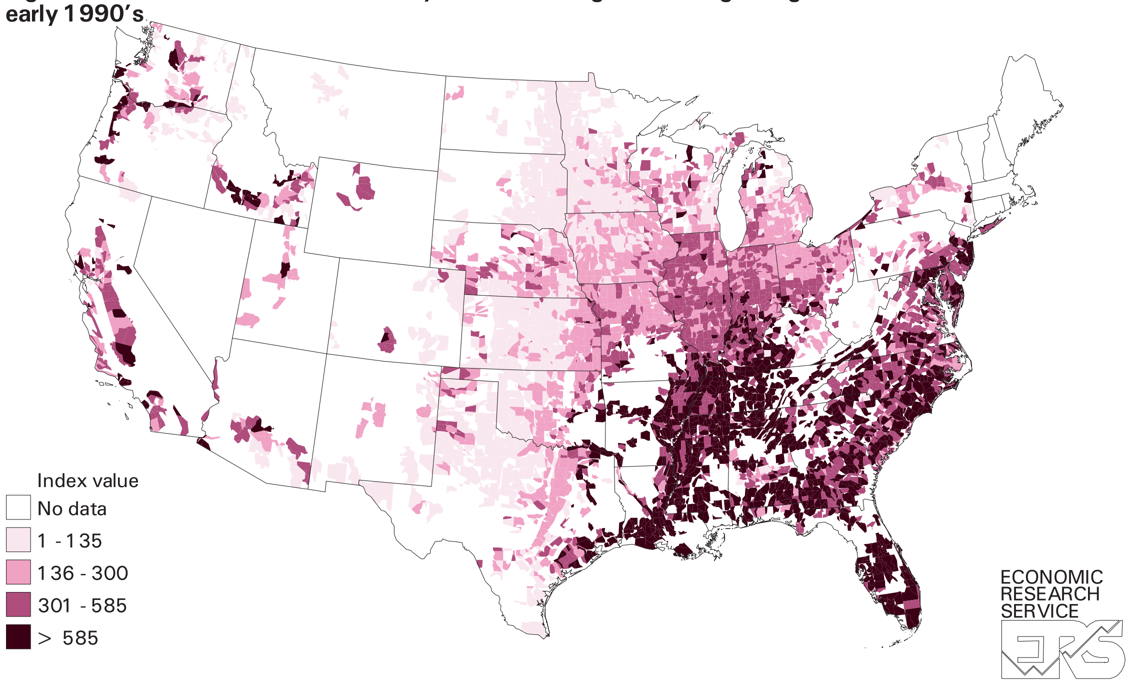
Residual nitrogen is that portion of nitrogen available from natural and manmade sources that is not taken up by crops. Residual nitrogen on cropland (nitrogen from both commercial and manure sources in excess of plant needs) is an indicator of potential nitrate availability for runoff to surface water or leaching to ground water. Regions with relatively high residual nitrogen include the Corn Belt, parts of the Southeast, and the intensively irrigated areas of the West (fig. 2.2.1). However, residual nitrogen by itself does not necessarily result in water quality problems. For example, warm, moist soil conditions in the Southeast tend to volatilize residual nitrogen to the atmosphere, and vegetative buffers capture excess nitrogen before it reaches water systems (Mueller and others, 1995). Therefore, nitrate levels in surface and ground water in the Southeast tend to be low, even though the vulnerability index and residual applications may be high. Regions with the greatest potential for nitrate contamination of groundwater include parts of the Lower Mississippi River, Southeast, and intensively irrigated areas of the West, reflecting areas of heavy

Figure 2.2.1--Residual soil nitrogen including nitrogen from manure, early 1990's



Source: USDA, ERS, estimated from 1990-93 cropping practices and other survey data.

Figure 2.2.2--Groundwater vulnerability index for nitrogen including nitrogen from manure, early 1990's



Source: USDA, ERS, estimated from NRCS National Resources Inventory and 1990-93 Cropping Practices Survey and other data.

use and/or areas with soils prone to leaching (fig. 2.2.2). A similar index is not available for surface water. However, areas with high residual nitrogen and low groundwater vulnerability are more likely to have a high surface-water vulnerability.

Agricultural activities are not the only cause of nutrient pollution. Other sources of nitrogen and phosphorus include point sources such as wastewater treatment plants, industrial plants, and septic tanks. Atmospheric deposition is another nonpoint source of nitrogen. Indeed, more than half the nitrogen emitted into the atmosphere from fossil fuel-burning plants, vehicles, and other sources is deposited on U.S. watersheds (Puckett, 1994). The relative shares of point and nonpoint sources vary by region, with commercial agricultural fertilizers the dominant source in some areas of the West, and in the central and southeastern United States (Puckett, 1994). Nitrogen discharges from point sources, based on National Pollution Discharge Elimination System permits, are concentrated in the Northeast, Lake States, and Appalachian regions, areas with major population centers and large concentrations of industry (fig. 2.2.3). Areas that may have to deal with both point and nonpoint sources include the eastern Corn Belt, the agricultural areas of California, parts of the Southeast, and the Mid-Atlantic region (including Chesapeake Bay).

USGS analysis of nutrients in surface waters over the 1980's shows different trends for nitrate and phosphorus in surface water (table 2.2.2) (Smith, Alexander, and Lanfear, 1993). Nitrate, in general, showed no statistically significant trend, which differs from the rise noted during 1974-81. This follows the pattern of agricultural nitrogen use, which rose sharply during the 1970's, peaked in 1981, and then stabilized. Phosphorus in water during the 1980's continued a decline noted in the 1970's, likely due to improved wastewater treatment, decreased phosphorus content of detergents, reduced phosphorus fertilizer use, and reduced soil erosion. Indeed, the rate of phosphorus decline in water in cropland areas was more than twice that in urban areas.

Pesticides

A wide variety of pesticides, with different levels of toxicity, solubility, and persistence, are applied to agricultural crops to control pests, fungus, and disease (see chapter 3.2, *Pesticides*). Pesticides are extremely important to production, but their use and/or misuse may lead to water quality problems. Pesticides move to water resources much as nutrients do. In addition, some pesticides can be carried into the air attached to dust or as an aerosol, and deposited into water bodies with rainfall.

Pesticide residues reaching surface-water systems may harm freshwater and marine organisms, damaging recreational and commercial fisheries. Pesticides in drinking water supplies pose risks to human health. Some commonly used pesticides have been identified as probable or possible human carcinogens. The presence of regulated pesticides above specified levels in water supplies requires additional treatment, placing added costs on water utilities and their customers. Enforceable drinking water standards have been established for 15 currently used pesticides, and more are pending (see box, "Maximum Contaminant Levels").

Well over 500 million pounds (active ingredient) of pesticides are applied annually on farmland (see chapter 3.2, *Pesticides*), and certain chemicals can travel far from where they are applied (Smith, Alexander, and Lanfear, 1993; Goolsby and others, 1993). Their presence in food and water has been highlighted and made an issue by environmental and consumer safety groups.

Maximum Contaminant Levels (MCL's)

Public Water Systems are required to make sure that the water they supply does not exceed the MCL for each chemical. These are enforceable standards, set by EPA, that are considered feasible and safe. MCL's have been set for 15 agricultural chemicals.

Chemical	MCL (mg/l)	Type chemical
Nitrate	10.0	fertilizer
Alachlor	.002	herbicide
Atrazine	.003	herbicide
Carbofuran	.04	insecticide
2,4-D	.07	herbicide
Dalapon	.2	herbicide
Dinoseb	.007	herbicide
Diquat	.02	herbicide
Endothall	.1	other
Glyphosate	.7	herbicide
Lindane	.0002	insecticide
Methoxychlor	.04	insecticide
Oxamyl	.2	insecticide
Picloram	.5	herbicide
Simazine	.004	herbicide