Chapter 2.2

Water Quality: Impacts of Agriculture

Marc Ribaudo and Robert Johansson

Agricultural production releases residuals, like sediment and pesticides, that may degrade the quality of water resources and impose costs on water users. Agriculture is the leading source of impairments in the Nation's rivers and lakes and a major source of impairments to estuaries. However, the extent and magnitude of this degradation is difficult to assess because of its nonpoint nature.

Introduction

The production practices and inputs used by agriculture can result in a number of pollutants entering water resources, including **sediment, nutrients, pathogens, pesticides, and salts**. Farmers, when making production decisions, often do not consider offsite impacts associated with runoff or leaching. Documenting the links between agriculture and water quality can help policymakers provide appropriate incentives to farmers for controlling pollution that originates on farms.

Agriculture is widely believed to have significant impacts on water quality. While no comprehensive national study of agriculture and water quality has been conducted, the magnitude of the impacts can be inferred from several water quality assessments. A general assessment of water quality is provided by EPA's 2000 Water Quality Inventory. Based on State assessments of 19 percent of river and stream miles, 43 percent of lake acres, and 36 percent of estuarine square miles, EPA concluded that agriculture is the leading source of pollution in 48 percent of river miles, 41 percent of lake acres (excluding the Great Lakes), and 18 percent of estuarine waters found to be water-quality impaired, in that they do not support designated uses. This makes agriculture the leading source of impairment in the Nation's rivers and lakes, and a major source of impairment in estuaries. Agriculture's contribution has remained relatively unchanged over the past decade.

The significance of water pollutants commonly produced by agriculture is suggested by information on impaired waters provided by States, tribes, and territories to EPA in accordance with Section 303(d) of the Clean Water Act. These are waters that do not meet water quality standards, and cannot meet those standards through point-source controls alone. The most recent information (2005) indicates that 25,823 bodies of water (stream reaches or lakes) are impaired nationwide. Pathogens, sediment, and nutrients are among the top sources of impairment, and agriculture is a major source of these pollutants in many areas.

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A U.S. Geological Survey (USGS) study of agricultural land in watersheds with poor water quality estimated that 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 instream criteria for supporting water-based recreation activities (Smith, Schwarz, and Alexander, 1994). Another USGS study found that structural changes in animal agriculture between 1982 and 1997 put upward pressure on stream concentrations of fecal coliform bacteria in many areas of the Great Plains, Ozarks, and Carolinas (Smith et al., 2005).

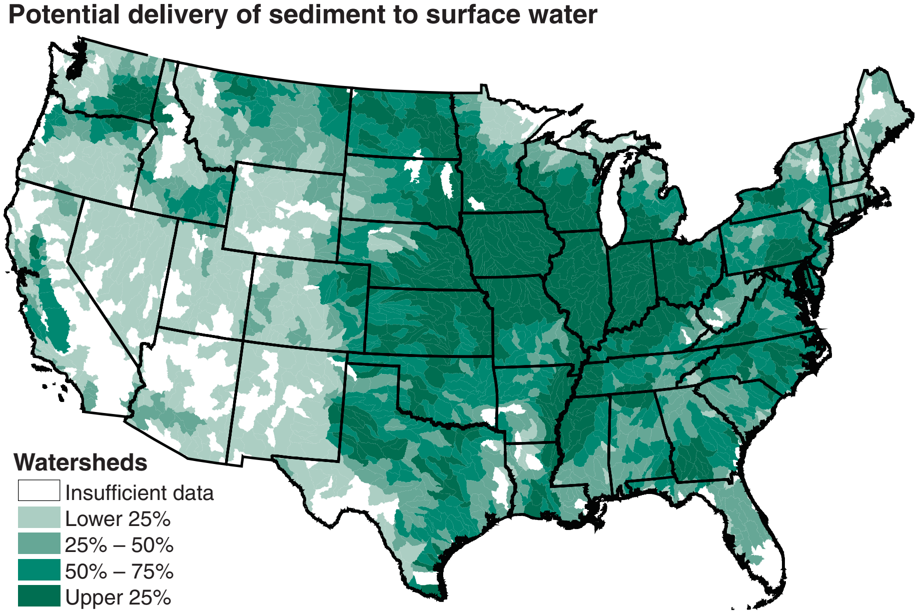
Major Agricultural Pollutants

Sediment is the largest contaminant of surface water by weight and volume (Koltun et al., 1997) and is identified by States as the second leading pollution problem in rivers and streams and the third leading problem in lakes (USEPA, 2002). Sediment in surface water is largely a result of soil erosion (see Chapter 4.2, "Soil Management and Conservation"), which is influenced by soil properties and the production practices farmers choose. Sediment buildup reduces the useful life of reservoirs. Sediment can clog roadside ditches and irrigation canals, block navigation channels, and increase dredging costs. By raising streambeds and burying streamside wetlands, sediment increases 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.

Regions with the greatest potential to discharge sediment from cropland to surface waters include parts of the Heartland, Mississippi Portal, and Prairie Gateway (see the ERS website for a description of Farm Resource Regions for a description) (fig. 2.2.1).

Figure 2.2.1

Potential delivery of sediment to surface water



Source: Economic Research Service, USDA, based on erosion data from 1997 National Resources Inventory, NRCS.

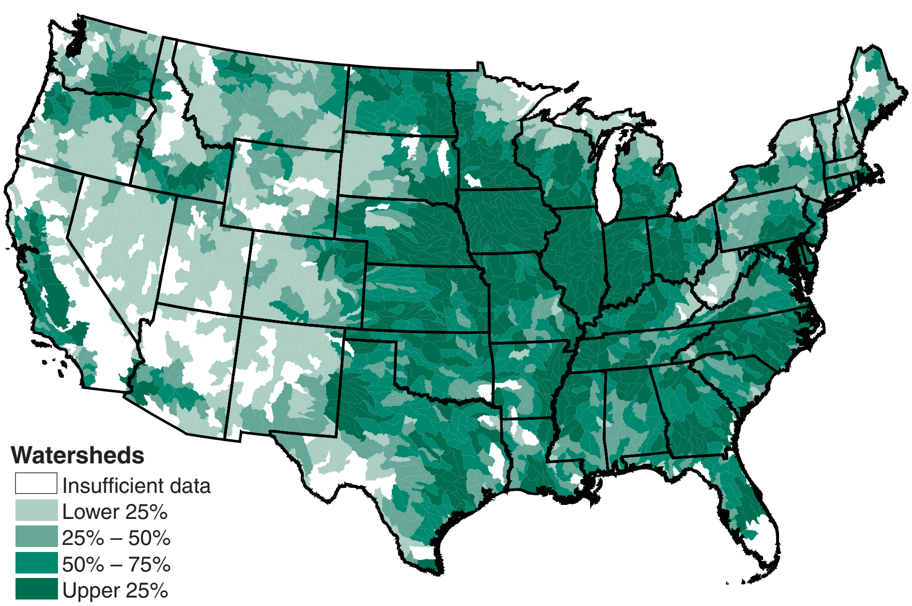
Nitrogen and **phosphorus** are important crop nutrients, and farmers apply large amounts to cropland each year. They can enter water resources through runoff and leaching. The major concern for surface-water quality is the promotion of algae growth (known as eutrophication), which can result in decreased oxygen levels, fish kills, clogged pipelines, and reduced recreational opportunities. USGS has found that high concentrations of nitrogen in agricultural streams are correlated with nitrogen inputs from fertilizers and manure used on crops and from livestock waste (see AREI Chapters 4.4, 4.5). Nine percent of domestic wells sampled by USGS's National Water Quality Assessment Program (NAWQA) during 1993-2000 had nitrate concentrations exceeding EPA's drinking water standard (maximum contaminant level or MCL) of 10 milligrams per liter, and agriculture was identified as the major source. EPA reported in its Water Quality Inventory that nutrient pollution is the leading cause of water quality impairment in lakes and a major cause of oxygen depletion in estuaries.

Watersheds with a high potential to deliver nitrogen to surface water are primarily in the Heartland and Southern Seaboard regions (fig. 2.2.2). Watersheds with a high potential to discharge nitrogen to ground water are primarily in the Southern Seaboard, Fruitful Rim, Heartland, and Prairie Gateway regions (fig. 2.2.3). Watersheds with a high potential to discharge phosphorus to surface water are located primarily in the Heartland, Southern Seaboard, and Northern Crescent regions (fig. 2.2.4).

Eutrophication and hypoxia (low oxygen levels) in the northern Gulf of Mexico have been linked to nitrogen loadings from the Mississippi River (NOS, NOAA, 1999). Agricultural sources (fertilizer, soil inorganic nitrogen, and manure) are estimated to contribute about 65 percent of the nitrogen loads entering the Gulf from the Mississippi Basin (Goolsby et al.,

Figure 2.2.2

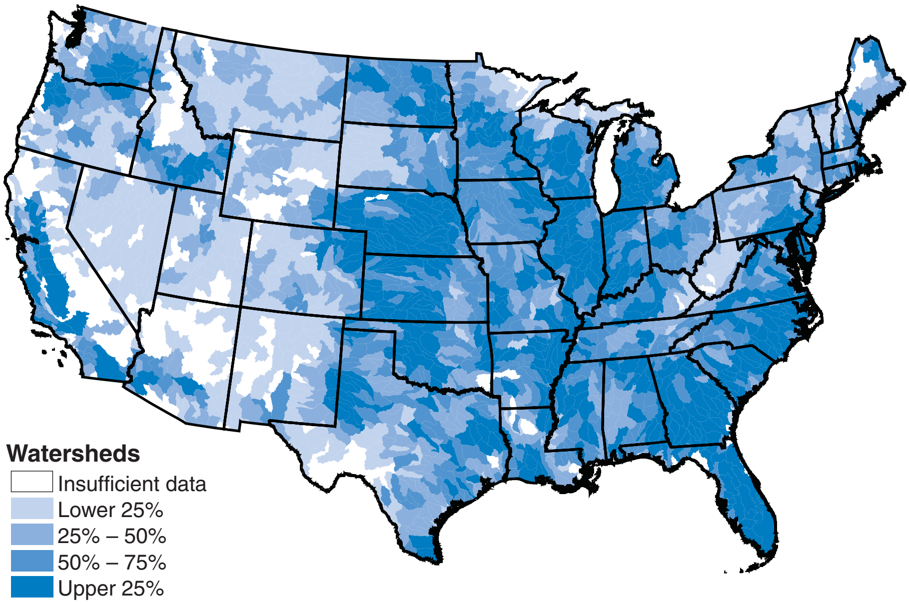
Potential delivery of nitrogen to surface water



Source: Economic Research Service, USDA, based on nitrogen data from Association of American Plant Food Control Officials (1998) and Kellogg et al. (2000).

Figure 2.2.3

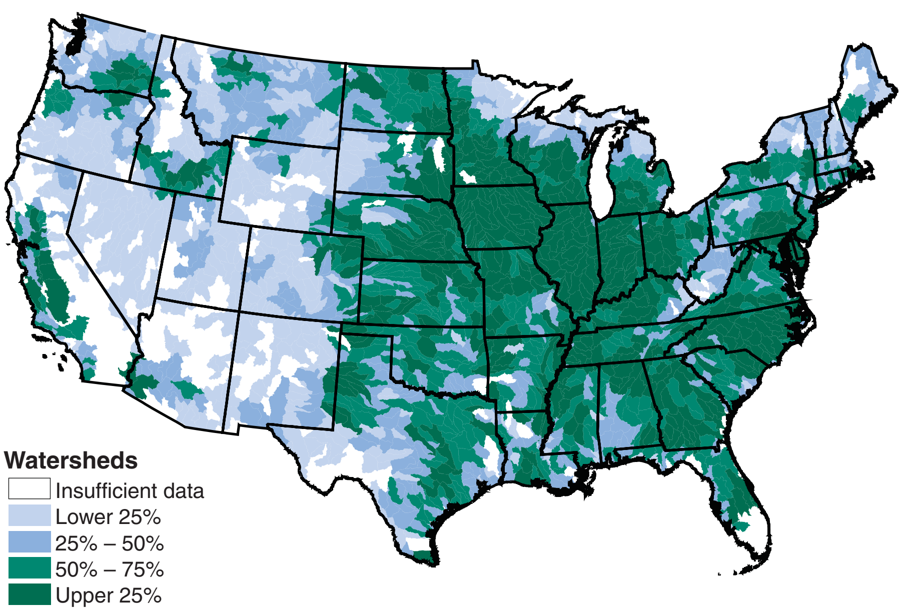
Potential nitrogen leaching to ground water



Source: Economic Research Service, USDA, based on nitrogen data from Association of American Plant Food Control Officials (1998) and Kellogg et al. (2000).

Figure 2.2.4

Potential delivery of phosphorus to surface water



Source: Economic Research Service, USDA, based on phosphorus data from Association of American Plant Food Control Officials (1998) and Kellogg et al. (2000).

1999). As much as 15 percent of the nitrogen fertilizer applied to cropland in the Mississippi River Basin makes its way to the Gulf of Mexico.

The Gulf of Mexico is not the only coastal area affected by nutrients. Recent research by the National Oceanographic and Atmospheric Administration has found that 44 estuaries (40 percent of major U.S. estuaries) exhibit highly eutrophic conditions, caused primarily by nitrogen enrichment (Bricker et al., 1999). These conditions occur in estuaries along all coasts, but are most prevalent in estuaries along the Gulf of Mexico and Mid-Atlantic coasts. Watersheds with a high potential to discharge nitrogen from agriculture to estuaries are located primarily in the Heartland, Mississippi Portal, and Southern Seaboard regions.

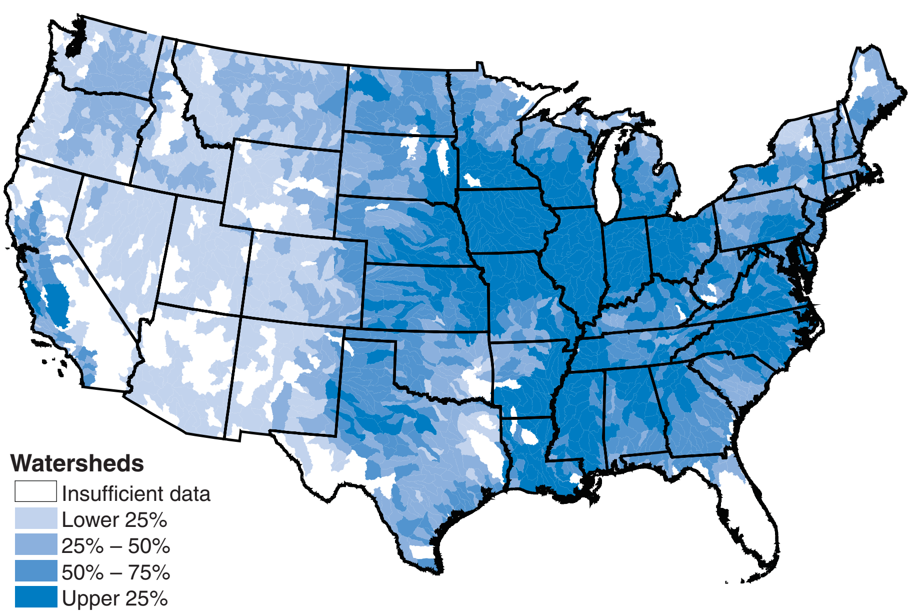
Farmers apply a wide variety of **pesticides** to control insects (insecticides), weeds (herbicides), fungus (fungicides), and other problems (see Chapter 4.3, "Pest Management"). Well over 500 million pounds (active ingredient) of pesticides have been applied annually on farmland since the 1980s, and certain chemicals can travel far from where they are applied. Pesticide residues reaching surface-water systems may harm freshwater and marine organisms, damaging recreational and commercial fisheries. Pesticides in drinking water supplies may also pose risks to human health. At least one of seven prevalent herbicides was found in 37 percent of the groundwater sites examined by USGS as part of the National Water Quality Assessment Program, but all at low concentrations.

Watersheds with a high propensity to discharge pesticides to surface water are located primarily in the Heartland and Mississippi Portal regions (fig. 2.2.5). Watersheds with a high propensity to discharge pesticides to ground water are primarily in the Heartland, Prairie Gateway, and Southern Seaboard regions (fig. 2.2.6).

Some irrigation water applied to cropland may run off the field into ditches and to receiving waters (see AREI Chapters 2.1 and 4.6). These irrigation return flows often carry **dissolved salts** as well as nutrients and pesticides into surface or ground water. Increased salinity levels in irrigation water can reduce crop yields or damage soils such that some crops can no longer be grown. Increased concentrations of naturally occurring toxic minerals—such

Figure 2.2.5

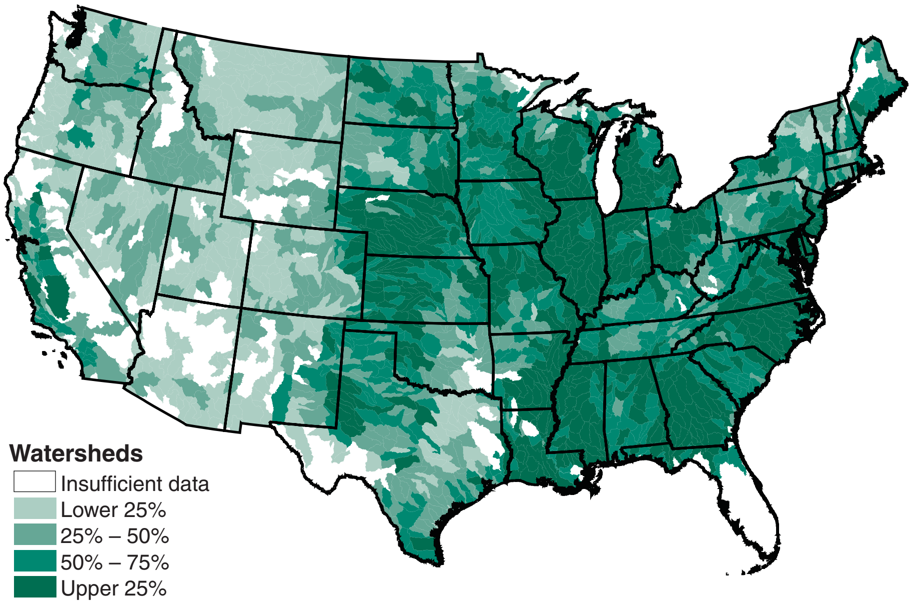
Potential pesticide runoff from cropland



Source: Economic Research Service, USDA, based on pesticide data from USDA surveys.

Figure 2.2.6

Potential pesticide leading from cropland



Source: Economic Research Service, USDA, based on pesticide data from USDA surveys.

as selenium, molybdenum, and boron—can harm aquatic wildlife and impair water-based recreation. Increased levels of dissolved solids in public drinking water supplies can increase water treatment costs, force the development of alternative water supplies, and reduce the lifespans of water-using household appliances.

Dissolved salts and other minerals are a significant cause of pollution in the Prairie Gateway and arid portions of the Fruitful Rim and Basin and Range. Selenium is of particular concern because of its adverse biological effects. Selenium in irrigation return flows was identified as the cause of mortality, congenital deformities, and reproductive failures in aquatic birds in Kesterson Reservoir in western San Joaquin Valley, California (Seiler et al., 1999). A Department of Interior study of the Western United States found that 4,100 square miles of land irrigated for agriculture is susceptible to selenium contamination, along with adjacent land that may receive return flows (Seiler et al., 1999). Affected areas are primarily in California, western Kansas, eastern Colorado, and western South Dakota.

The possibility of **pathogens** contaminating water supplies and recreation waters is a continuing concern. Bacteria are the largest source of impairment in rivers and streams, according to EPA's water quality inventory. Potential sources include inadequately treated human waste, wildlife, and animal feeding operations (see Chapter 4.5, "Animal Agricultural and the Environment"). Diseases from micro-organisms in livestock waste can be contracted through direct contact with contaminated water, consumption of contaminated drinking water, or consumption of contaminated shellfish. Bacterial, rickettsial, viral, fungal, and parasitic diseases are potentially transmissible from livestock to humans (CAST, 1996). Fortunately, proper animal management practices and water treatment minimize this risk. However, protozoan parasites, especially *Cryptosporidium* and *Giardia*, are important sources of waterborne disease outbreaks. *Cryptosporidium* and *Giardia* may cause gastrointestinal illness, and *Cryptosporidium* may lead to death in persons with compromised immune systems. These parasites have been commonly found in beef herds and *Cryptosporidium* is widespread on dairy operations (USDA, APHIS, 1994; Juranek, 1995).

Government Response to Agricultural Pollution

While agriculture's impacts on water resources are widespread and considered to be significant, the control of agricultural pollution is a challenge. The primary reason for this is that pollution from agriculture is generally "nonpoint" in nature. Nonpoint-source pollution has four characteristics that have an important bearing on the design of policies for reducing it.

- Nonpoint emissions are generated diffusely over a broad land area. These emissions leave from fields in so many places that it is generally not cost effective to accurately monitor emissions using current technology.

- Nonpoint emissions (and their transport to water or other resources) are subject to significant natural variability due to weather-related events and other environmental characteristics.

- Nonpoint emissions and the associated water quality impacts depend on many site-specific characteristics, such as soil type, topography, proximity to the water resource, climate, etc.

- Nonpoint pollution problems are often characterized by a very large number of nonpoint polluters.

The difficulties in measurement, variability of discharges, and the site-specific nature make regulations used for point sources (factories and sewage treatment plants) largely inappropriate for nonpoint sources. As a consequence, water quality laws such as the Clean Water Act (see Chapter 5.7, "Federal Laws Protecting Environmental Quality") generally do not regulate agricultural pollution but, instead, pass most of the responsibility on to the States. This has resulted in quite varied responses, reflecting the States' particular resource concerns and organizational capacity. Thirty-three States have laws with provisions that regulate agriculture under certain conditions, such as when voluntary approaches fail to achieve water quality goals. States commonly use technology standards that require farmers to implement conservation plans that contain recommended management practices (Ribaudo and Caswell, 1999), such as conservation tillage, nutrient management, pesticide management, and irrigation water management. These plans can be required statewide, or in areas particularly vulnerable to agricultural pollution.

By contrast, the Federal Government relies primarily on voluntary approaches, such as education and financial assistance (policy instruments), to encourage farmers to protect water quality. Major USDA programs such as the Environmental Quality Incentive Program and Conservation Security Program are important sources of information and assistance for farmers concerned with water quality (see Chapter 5.4, "Working-Land Conservation Programs").

Between 1997 and 2004, 37 percent of EQIP funds were devoted to water quality and conservation.

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