Chapter 4.5

Animal Agriculture and the Environment

Marc Ribaudo and Noel Gollehon

Animal production produces a number of pollutants that can affect the quality of air and water resources. Environmental/conservation policies and programs provide incentives to farmers to reduce pollution from animal operations.

Introduction

Animal production industries have seen substantial changes over the past several decades, the result of domestic/export market forces and technological changes. The number of large operations has increased, and animal and feed production are increasingly separated in terms of both management and geography. Concern that these changes are harming the environment has prompted local, State, and Federal policies (see Chapter 5.7, "Federal Laws Protecting Environmental Quality") and programs to control pollution from animal production facilities.

Trends in Animal Production and Manure Nutrients

Changes in the structure of livestock and poultry production are behind many of the current concerns about animals and the environment. Structural changes have been driven by both innovation and economies of size (McBride and Key, 2003). Organizational innovations, such as production contract arrangements, enable growers to access the capital necessary to adopt innovative technologies and garner economies of size, with greater profit potential. The significant economic benefits from vertical coordination, particularly for poultry and swine operations, have led to both larger operations and greater geographic concentration of animals.

The number of U.S. farms with confined animals (called animal feeding operations, or AFOs) has declined steadily from 435,000 in 1982 to 213,000 in 1997 (Gollehon et al., 2001). Declines occurred in all sectors, but primarily in the very small and small farm sizes (see box, "Size Groupings"). This decline in farms has been accompanied by a 10-percent increase in the number of confined animal units (AUs, defined as 1,000 pounds of live weight) (fig. 4.5.1). A decline in AUs on very small and small farms was more than offset by growth on medium-sized farms and large farms (Gollehon et al., 2001).

The regional distribution of confined animals also changed between 1982 and 1997. Animal populations in the Prairie Gateway and Southern Seaboard regions increased by 2 million (40 percent) and 1.7 million (70

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Size Groupings

One animal unit is defined as 1,000 lbs live weight (e.g. 1 AU = 1.14 feedlot beef, 0.74 dairy cow, 9.09 swine for slaughter, or 455 broilers).

Animal operations are classified as:

Very small, less than 50 AU

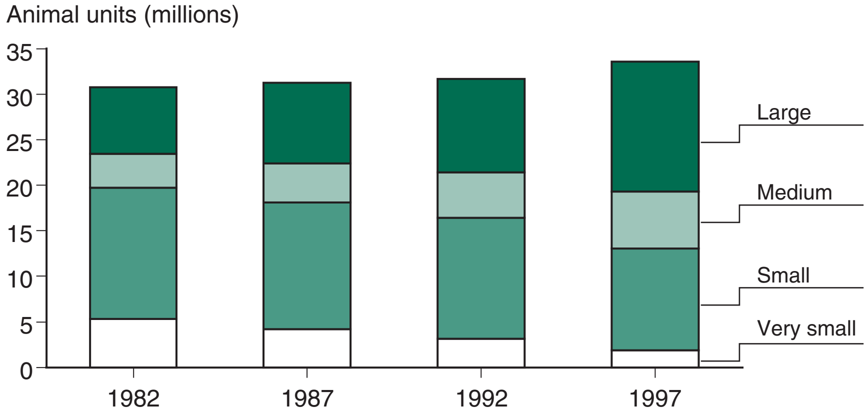
Small, 50-299 AU

Medium, 300-999 AU

Large, more than 1,000 AU

Figure 4.5.1

Confined animal units by size of animal operation, 1982-97



Source: Census of Agriculture and ERS.

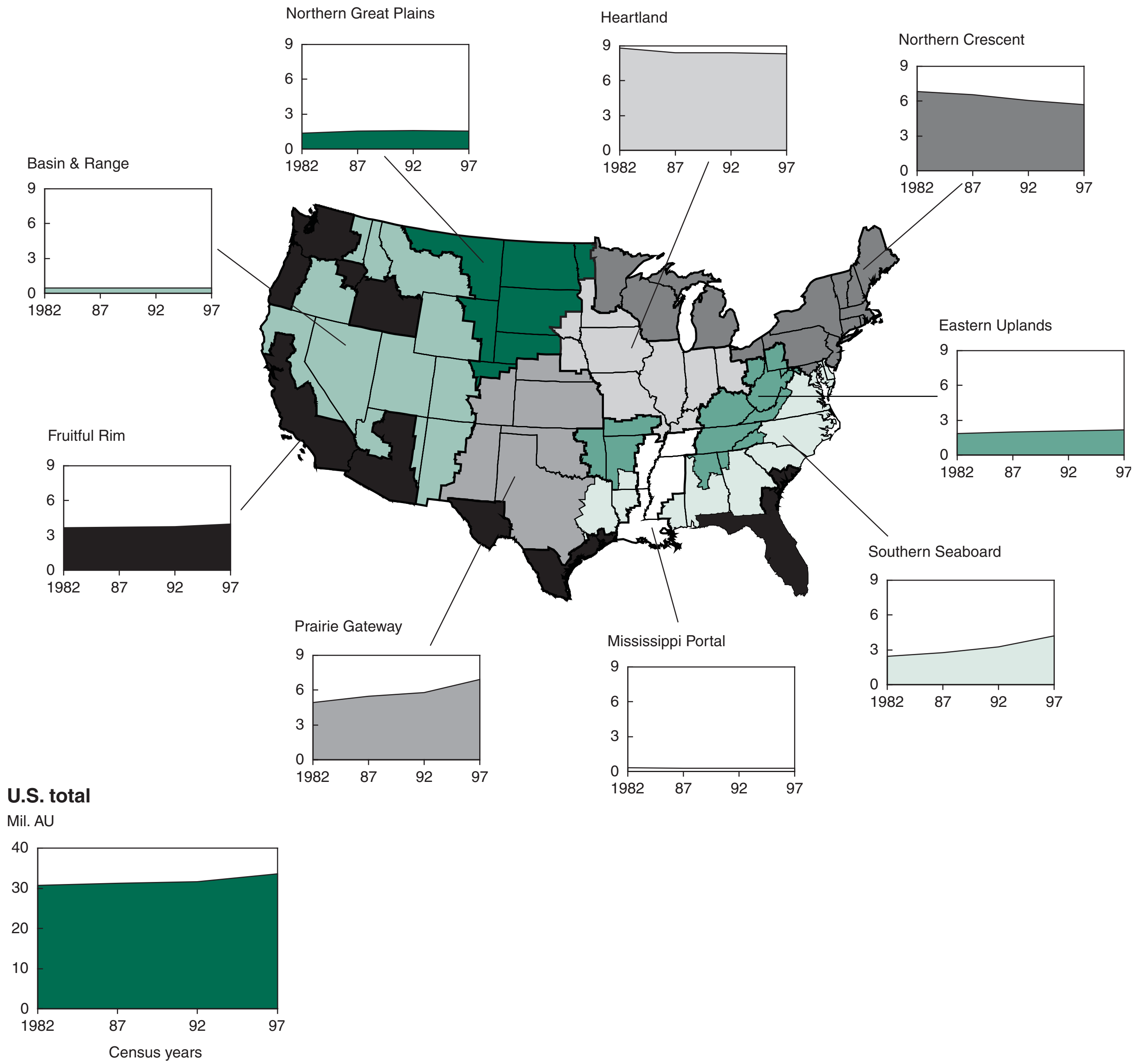
percent) animal units over 1982-97 (fig. 4.5.2). Only the Northern Crescent and Heartland regions exhibited significant declines.

The innovation and economies of size that underlie changes in the livestock and poultry sector also served to separate animal production from crop production. Large, specialized facilities today focus on producing animals and purchase most of their feed from off the farm. This means there is generally less land on the animal farm on which to spread manure. The amount of land per animal unit declined nearly 40 percent across all animal types between 1982 and 1997, from 3.6 to 2.2 acres per AU. (See Gollehon et al, 2001, for additional information on trends).

Environmental Impacts of Animal Production

The major source of environmental degradation from confined animal production is the wastes (manure, urine, bedding material) that are produced. Animal waste can be transmitted through runoff of nutrients, organic matter, and pathogens to surface water; leaching of nitrogen and

Figure 4.5.2
Confined animal units by ERS Resource Region, 1982-97



Source: Economic Research Service, USDA.

pathogens to ground water; and volatilization of gases and odors to the atmosphere. Pollutants may originate at production houses/lots where animals are kept; manure storage structures such as tanks, ponds, and lagoons; or land where manure collects or is applied.

The major pollutants include:

- **Nutrients—**Nitrogen and phosphorus are essential plant nutrients, but can degrade water quality by causing eutrophication (see Chapter 2.2, “Water Quality: Impacts of Agriculture).
- **Ammonia—**A pungent, colorless gas that can be a health hazard to humans and animals at high concentrations, and a precursor for fine particulates (haze) in the atmosphere. It also contributes to soil acidification and eutrophication.
- **Hydrogen sulfide—**A colorless gas also hazardous to humans and animals.
- **Methane—**A nontoxic, odorless gas that contributes to global warming (greenhouse gas).
- **Odor—**A nuisance associated with animal production facilities. Odorous gases consist of a host of compounds (over 160) that originate from manure in animal housing, manure storage units, and land application.
- **Pathogens**—Threats to human health that are often contained in manure. Some of the pathogens that pose a threat to human health include the protozoan parasites *Cryptosporidium* and *Giardia* and some bacteria species such as *Salmonella*, *E. coli,* and *Campylobacter*.

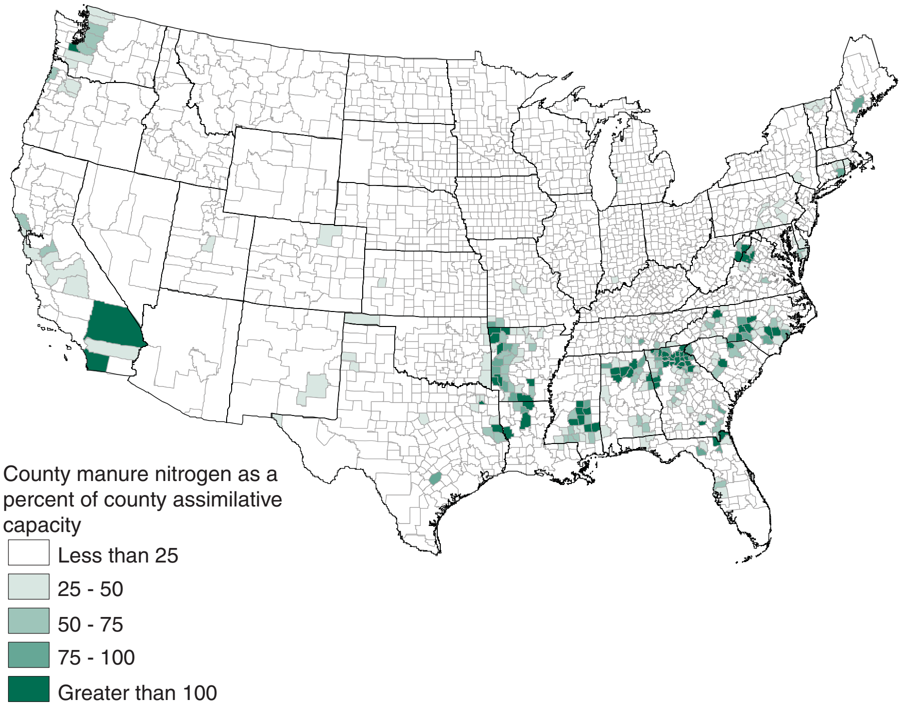
Manure Production and Excess Nutrients

Two indicators of potential environmental degradation from animal feeding operations are total nitrogen excreted and excess nitrogen and phosphorus. Total nitrogen is an indicator of the potential for both air and water pollution from the entire operation (production facility, manure storage, and land application). Excess nutrients are manure nutrients produced on the farm in excess of the farm’s crop needs. Excess nutrients are susceptible to running or leaching off the field and into water resources unless steps are taken to move the manure off the farm to additional land or to other industrial uses such as energy production or commercial fertilizer production.

In 1997, animal feeding operations controlled 73 million acres of cropland and permanent pasture. This land was estimated by Gollehon et al. (2001) to have the capacity to assimilate only 40 percent of the nitrogen and 30 percent of the phosphorus in the manure recoverable from animal production facilities and available as a crop fertilizer. Large farms, which constitute 2 percent of the total number of farms, accounted for almost half of the excess onfarm nutrients.

Figure 4.5.3

Excess manure nitrogen as a share of county assimilative capacity, 1997

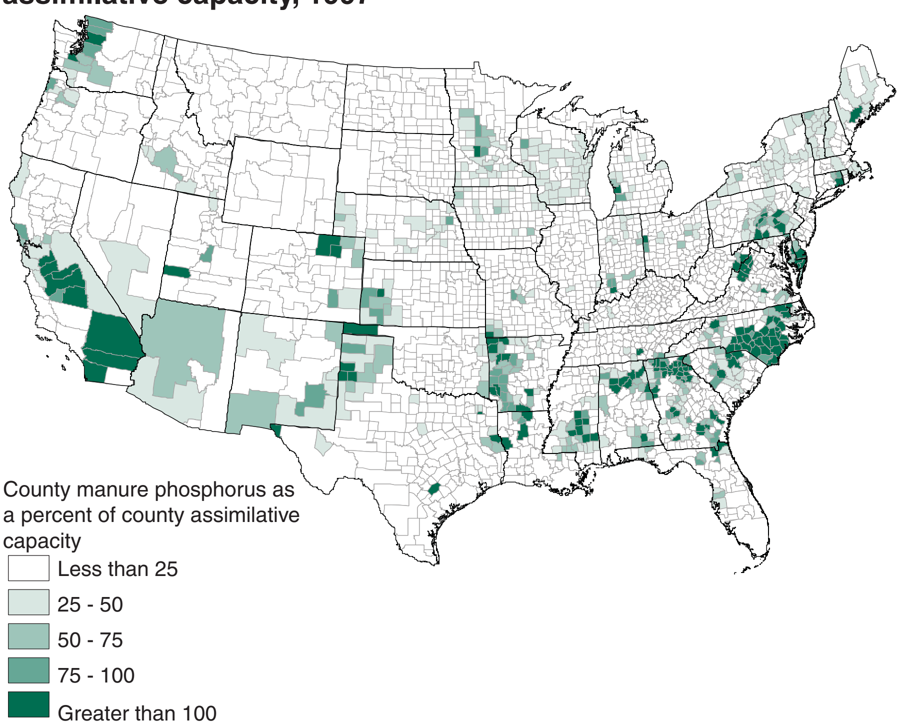


Some counties are combined to meet disclosure criteria.

Source: Economic Research Service, USDA.

Figure 4.5.4

Excess manure phosphorus as a share of county assimilative capacity, 1997



Some counties are combined to meet disclosure criteria.

Source: Economic Research Service, USDA.

In 1997, 68 counties had manure nitrogen levels that exceeded the assimilative capacity of the entire county's crop and pasture land (fig. 4.5.3). Many more counties (152) have surplus manure phosphorus (fig. 4.5.4).

In these areas, it may be difficult to find enough land locally to spread manure without posing a risk to water quality. Research suggests that producers may have to haul manure extended distances in order to apply manure to land at agronomic rates (Ribaudo et al., 2003).

Manure's Contribution to Environmental Degradation

While a nationwide study has yet to be completed, a number of studies have indicated that animal operations are significant contributors to water quality impairments in several regions. States reported to the Environmental Protection Agency (EPA) in 1996 that animal operations (feedlots, animal feeding operations, and animal holding areas) were a major factor in 5 percent of impaired rivers and streams, and a contributing source in 20 percent of rivers and streams reported as being impaired (U.S. EPA, 1998).[1] A United States Geological Survey (USGS) study of nitrogen loadings in 16 watersheds found that manure was the largest source in 6, primarily in the Southeast and Mid-Atlantic States (Puckett, 1994). In the Mississippi Basin, animal manure was estimated to contribute 15 percent of the nitrogen load entering the Gulf of Mexico; nitrogen is the suspected cause of a large zone of hypoxic waters (Goolsby et al., 1999). Monitoring by USGS in the National Water Quality Assessment Program found that the highest concentrations of nitrogen in streams occurred in agricultural basins, and were correlated with nitrogen inputs from fertilizers and manure (USGS, 1999). An analysis of fecal coliform bacteria in streams found that concentrations were partly a function of the number of both confined and unconfined animals in a watershed (Smith et al., 2005).

[1]U.S. EPA's assessment relies on State self-reporting, which is incomplete and inconsistent between States (U.S. GAO, 2000). The Clean Water Act requires that such a report be submitted to Congress every 2 years.

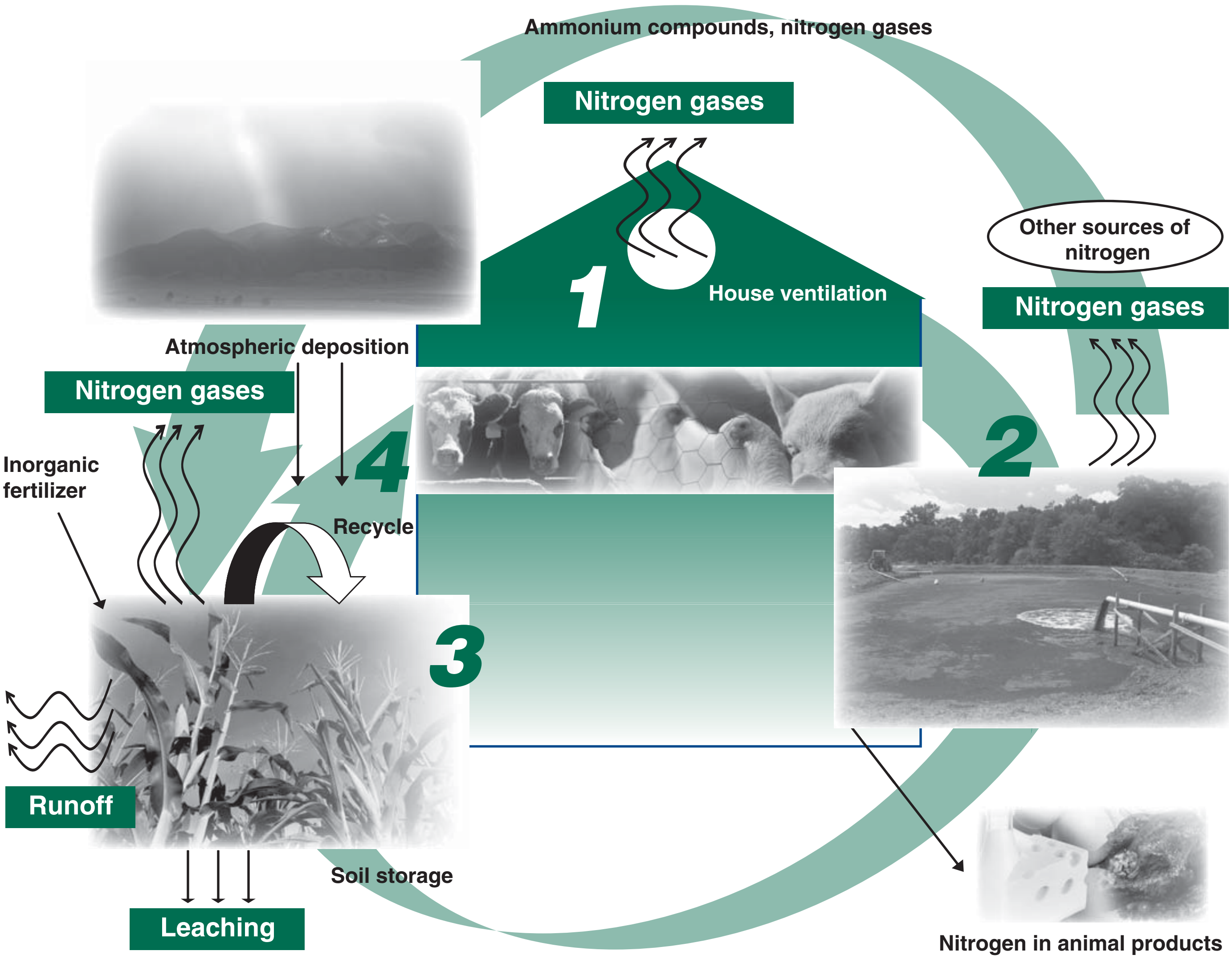
The impact of gases and odor from animal feeding operations on human health or the environment has been difficult to determine because data on emissions are generally lacking (Jacobson et al., 1999). Animal waste in the United States has been estimated to contribute about 80 percent of all anthropogenic ammonia emissions, 25 percent of nitrous oxide emissions, and 18 percent of methane emissions (Battye et al., 1994; van Aardenne et al., 2001).

Water-Air Interactions

Emissions to water and to the atmosphere are not independent events, but are linked by the biological and chemical processes that produce the various compounds. For example, nitrogen excreted from an animal can follow any number of pathways and enter water as nitrate or the atmosphere as ammonia, nitrous oxide, nitric oxide, or as part of a volatile organic compound. Reducing nitrogen movement along one pathway by changing its form will increase nitrogen movement along a different path (fig. 4.5.5). For example, reducing ammonia losses from a field by injecting waste directly into the soil increases the amount of nitrogen available for crop production, but may increase the risk of nitrate entering

Figure 4.5.5

Nitrogen follows many pathways in a livestock operation



Source: Economic Research Service, USDA.

surface and ground water and nitrous oxide entering the atmosphere. The efficiency of manure management will depend on how these interactions are addressed. (For more information on this, see Aillery et al, 2005.)

Reducing Pollutant Losses

A number of practices are available for reducing gaseous emissions and runoff/leaching from animal feeding operations.

- ***Diet manipulation—***Feed additives and more efficient nutrient utilization in animals can reduce the amount of nitrogen and phosphorus in manure. This helps reduce the odor and ammonia emissions from production houses, and simplifies manure management for protecting water quality at all stages of handling and disposal.

- ***Chemical additive—***Different chemicals can be added to manure during collection in order to bind nutrients, thus reducing odorous compounds and ammonia emissions. By reducing atmospheric emissions, the nitrogen content of manure increases, increasing its value as a fertilizer. But the higher nitrogen content can also increase the cost of applying manure at agronomic rates to protect water quality.

- ***Air treatment—***Trapping air vented from production houses and treating it before discharge to the atmosphere can reduce odorous compounds, ammonia, and other gases.

- ***Tank and lagoon cover***—Covering storage tanks and lagoons can greatly reduce the discharge of ammonia and other gases. Conserving nitrogen in tank and lagoon waste increases the value of the effluent as a fertilizer, but can increase the cost of managing manure to protect water quality.

- ***Solid-liquid separation—***Separating urea from solid fecal matter using sedimentation basins or mechanical methods avoids some of the reactions that cause the formation of ammonia and odor. Separation also reduces the cost of moving waste to land for efficient disposal.

- ***Manure incorporation/injection—***Rapidly incorporating manure into the soil after spreading by plowing or disking—or injecting manure liquids or slurries directly into the soil—reduces odor, ammonia emissions, and the potential for runoff to surface waters. However, incorporation/injection may also increase the risk of nitrogen leaching to ground water.

- ***Comprehensive nutrient management—***Nutrient management matches the combined nutrient applications from manure and commercial nutrient sources to crop needs so that as few nutrients as possible are lost to the environment.

An important characteristic of most of these practices is that in reducing one type of emission, they may increase another type of emission. Such interactions can have an important bearing on the design of policies for protecting environmental quality.

Policy Responses

Federal, State, and local governments have responded to the environmental problems posed by animal operations through a variety of regulations and conservation programs (see Chapter 5.7, “Federal Laws Protecting Environmental Quality”). The Environmental Protection Agency introduced new Clean Water Act regulations in 2003 for controlling runoff of manure nutrients from the largest animal feeding operations. Concentrated animal feeding operations (CAFOs, defined as those operations requiring a pollution discharge permit) develop and implement a nutrient management plan that bases nutrient applications on agronomic rates. This provision requires CAFOs to spread their manure over a much larger land base than they are currently using, and most will need to move their manure off farm. Livestock and poultry farms’ annual net income could decline by more than $1 billion (3.2 percent) if crop producers are reluctant to use manure as a nutrient source (Ribaudo et al., 2003).

USDA is using voluntary approaches such as education and financial incentives to encourage improved manure handling practices on all animal feeding operations (AFOs). Sixty percent of Environmental Quality Incentive Program (see Chapter 5.4, "Working-Land Conservation Programs") funds are earmarked to environmental concerns on animal operations.

Many States have enacted regulations that address environmental issues associated with AFOs, including some not addressed at the Federal level. Some States had manure land application requirements in place prior to EPA's 2003 regulations, with coverage often extended to smaller AFOs. Odor is a persistent local issue, and many States are using setback requirements to separate animal operations from residential areas. Ammonia emissions from large animal feeding operations have prompted California to enact regulations in the San Joaquin Valley to protect heavily populated areas downwind.

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