

**Manure Management for Water Quality: Costs to Animal Feeding Operations of Applying Manure Nutrients to Land.** By Marc Ribaldo, Noel Gollehon, Marcel Aillery, Jonathan Kaplan, Robert Johansson, Jean Agapoff, Lee Christensen, Vince Breneman, and Mark Peters. U.S. Department of Agriculture, Economic Research Service, Resource Economics Division. Agricultural Economic Report 824.

## **Abstract**

Nutrients from livestock and poultry manure are key sources of water pollution. Ever-growing numbers of animals per farm and per acre have increased the risk of water pollution. New Clean Water Act regulations compel the largest confined animal producers to meet nutrient application standards when applying manure to the land, and USDA encourages all animal feeding operations to do the same. The additional costs for managing manure (such as hauling manure off the farm) have implications for feedgrain producers and consumers as well. This report's farm-level analysis examines onfarm technical choice and producer costs across major U.S. production areas for hauling manure to the minimum amount of land needed to assimilate manure nutrients. A regional analysis then focuses on off-farm competition for land to spread surplus manure, using the Chesapeake Bay region as a case study. Finally, a sectorwide analysis addresses potential long-term structural adjustments at the national level and ultimate costs to consumers and producers.

**Keywords:** manure management costs, price and quantity adjustments, water quality, animal waste, manure nutrients, excess nutrients, confined animals, CAFO, manure nitrogen, manure phosphorus, manure use, assimilative capacity, nutrient management plan

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## Executive Summary

U.S. farmers are world leaders in the production of animal products. The United States has the largest fed-cattle industry in the world, and is the world's largest producer of beef. The U.S. is also the world's largest producer of poultry meat and the third largest producer of pork products. Livestock and poultry production cuts widely across all elements of the farm sector; more than half of U.S. farms raise animals, and animal products account for about half of the total receipts for agriculture. In 2002, U.S. farmers produced nearly 86 billion pounds of meat and poultry products, more than 70 billion table eggs, and 170 billion pounds of milk products. But in supplying households with hamburgers, pork chops, and ice cream, livestock and poultry farms also generate more than 350 million tons of manure that must be disposed of.

When used as a fertilizer, livestock and poultry manure can provide valuable organic material and nutrients for crop and pasture growth. However, those same nutrients—nitrogen and phosphorus—can degrade water quality if they are overapplied to land and enter water resources through runoff or leaching. New regulations—enacted by the Environmental Protection Agency in February 2003—require the largest confined animal operations to meet nutrient application standards when disposing of their manure by spreading it on cropland.

The EPA regulations affect only those largest farms designated “concentrated animal feeding operations,” or CAFOs. While making up only about 5 percent of animal feeding operations, they contain 50 percent of all animals and produce over 65 percent of excess nutrients. If all CAFOs meet the nutrient standards outlined in the new regulations, increases in production costs could be felt throughout the food and agricultural system. We evaluated these costs at the farm, regional, and national levels to provide a full perspective on potential economic impacts.

- *Complying with the EPA regulations will require 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. Only 18 percent of large hog farms and 23 percent of large dairies are currently applying manure on enough cropland to meet a nitrogen standard. Further, even if they spread manure over their entire land base, only 20-50 percent of all large hog farms operate enough land to meet land application standards, depending on whether a nitrogen or phosphorus standard is to be met. The new regulations will require even more large dairies to move their manure off farm; at best, just slightly more than one-quarter of all large dairies manage an adequate land base to spread their manure on and fewer than 2 percent have an adequate land base to meet a strict phosphorus-based standard. Similar results would be expected for beef and poultry.*
- *Livestock and poultry farms' annual net income could decline by more than \$1 billion (around 3 percent), but the precise outcome depends greatly on the extent to which cropland operators are willing to substitute manure for commercial fertilizers, and the degree to which revenue from sales of higher priced animal products mitigates increases in production costs. Livestock and poultry producers' net income is predicted to decline by \$1 billion if 40 percent or more of all U.S. cropland is available for spreading manure. On the other hand, if cropland farmers accept manure on only 20 percent of cropland, the per-animal cost to CAFOs for disposing of their manure would increase such that they would likely reduce their production. The net effect of increased manure transportation costs and decreased production levels, offset by increased prices for animal products, could result in a small (0.3 percent) increase in net revenues to livestock and poultry producers that remain in production.*

- *Phosphorus-based standards are more costly than nitrogen-based standards.* A farm-level analysis of hog and dairy CAFOs suggests that their production costs could increase by twice as much, on average, under a phosphorus-based versus a nitrogen-based standard. The higher cost associated with the phosphorus standard reflects higher concentrations of phosphorus in manure than of nitrogen, relative to crop nutrient needs. More land is required to spread manure under a phosphorus standard than under a nutrient standard because less manure is needed per acre to satisfy crops' phosphorus needs. The cost gap between the nitrogen and phosphorus standards would shrink if regulations allow phosphorus to accumulate in the soil profile.
- *Production cost increases will vary by species and by region.* In general, costs will be lower in the Corn Belt than in other regions. Crop production is more prevalent there and livestock concentrations are lower, so manure does not have to be hauled as far off the farm to reach adequate land. Costs to hog producers, in particular, will depend greatly on where farms are located. Costs are highest in the Mid-Atlantic where hog densities are greater and cropland is not as common a land use in counties where hogs are raised. Under a phosphorus standard and with 20 percent of crop operators willing to take manure, hog farms in the Mid-Atlantic, South, and West would experience a 2- to 3-percent increase in production costs, while hog farmers in the eastern and western Corn Belt would be virtually unaffected. Large dairy farms tend to be more homogeneous across the regions we examined, so dairies in the North and South both experience similar increases in production costs (about 3 percent for a phosphorus-based standard when 20 percent of crop operators accept manure).

Crop producers are not subject to the new EPA manure management regulations, but are likely to experience indirect effects. Crops are linked to animal production in two ways. Many crops are used as livestock and poultry feed. Any changes in livestock and poultry production in response to the environmental regulations could result in shocks to the feed markets. On the other hand, cropland farmers could reap the benefits of using manure as a nutrient source. As adjustments filter through the food and agricultural system, consumers could also be affected.

- *Net returns in the crop sector could increase by more than \$400 million as manure nutrients replace commercial fertilizer.* While small price increases for some crops are predicted, and would have a positive effect on revenues in the crop sector, the \$400 million gain is primarily associated with savings due to reduced commercial fertilizer use. Of course, commercial fertilizer suppliers would feel some portion of that gain as a loss in revenues.
- *Sectorwide adjustments in livestock and poultry production, and related changes in feed crop production, could result in price shifts that would be felt throughout the food and agricultural system.* If farmers' willingness to accept manure is limited, prices for animal products could increase by up to 6 percent, while prices for feed crops (e.g., corn, oats, and soybeans) could increase by 1 to 3 percent. However, if manure is accepted on 40 percent or more of cropland in each region, prices for crops and animal products are all likely to remain unchanged. Results will also depend on domestic and international market dynamics (which influence price responsiveness).
- *Consumers could bear the cost of higher prices for animal products, but they could also benefit from improved water quality.* Although livestock and poultry producers could see higher net revenues if cropland farmers' willingness to accept manure is limited, that net benefit reflects increased consumer costs. The result is a net eco-

conomic loss when consumer costs and producer benefits are added together. This analysis does not quantify the value of environmental benefits.

Although EPA regulations apply only to large operations, USDA policy encourages all animal feeding operations (AFOs) to adopt nutrient standards voluntarily, and provides financial assistance for doing so. Bringing all AFOs under the umbrella of farms meeting nutrient standards would increase the amount of manure needing transportation, and increase the demand for cropland to spread it on. In some regions, the competition for land could be severe.

- *For most farms trying to meet a nutrient standard, the most immediate problem is finding enough land to spread manure on.* Transporting manure to adequate land is the largest cost for meeting a standard. While many small and medium-size farms control enough land to meet nutrient standards, most are not applying manure on all of their cropland, thereby over-applying manure nutrients on the portion that receives manure.
- *Production cost increases for small and medium-size animal feeding operations are generally less than 1 percent.* This result holds under all scenarios we evaluated, including the entire range of assumptions about cropland farmers' willingness to accept manure, because small and medium-size AFOs generally have to move a much smaller portion of their manure off the farm.
- *If all AFOs meet a nutrient standard, costs to the livestock and poultry sector could exceed \$2 billion (7.1 percent), and price increases to consumers would be greater than if only CAFOs met the standard.* Although production cost increases could be relatively small at the farm level for small and medium-size AFOs, the increased demand for receiving cropland means that costs to CAFOs would be larger than if they were the only operations attempting to apply their manure at agronomic rates. In addition, the large number of AFOs suggests that even small costs at the farm level could translate into substantial costs sectorwide.
- *Competition for land for spreading manure could be severe in regions with high concentrations of animals.* Animal feeding operations in 2 to 5 percent of U.S. counties produce more manure nutrients than can be absorbed by all of those counties' cropland and pasture. Those counties are primarily in North Carolina, States surrounding the Chesapeake Bay (Virginia, Maryland, and Delaware), Southeastern States (such as Georgia, Alabama, and Arkansas), and in California. Consequently, operations in those regions would have to compete for available land if all manure were to be spread at agronomic rates. This could result in farther travel and higher costs.
- *The willingness of cropland operators to accept manure is critical in determining whether land application is feasible for disposing of all manure in regions with high animal concentrations.* For example, in the Chesapeake Bay Watershed, under a phosphorus-based standard, if less than 60 percent of cropland receives manure because of cropland operator preferences, there would not be sufficient land for spreading manure within a 90-mile radius of manure production.
- *Industrial processing of poultry litter might be a feasible alternative when the transportation costs for hauling manure to available land are high.* Analysis for the Chesapeake Bay Watershed suggests that cost savings from not having to haul manure long distances could be sufficient, on a per-ton basis, to cover the annualized capital costs of industrial facilities such as fertilizer plants. Whether such plants are economically viable in the long run is uncertain, but a closer look at such alternatives seems warranted by public agencies concerned with manure management and water quality.

- *AFOs are being encouraged by USDA to adopt nutrient standards voluntarily, so the estimated cost increases suggest that many AFOs will not have sufficient incentive to voluntarily meet nutrient standards without financial assistance.*
- *Financial assistance may be available to all animal operations, which would offset some of the costs associated with improved manure management.* USDA's Environmental Quality Incentives Program (EQIP) is designed, in large part, to provide relief to animal operations attempting to comply with EPA regulations. EQIP provides technical assistance, cost-share payments, and incentive payments to assist crop and livestock producers with environmental and conservation improvements on the farm, with 60 percent of the program's funding (\$1 billion per year) allocated to addressing livestock issues. To the extent that livestock and poultry producers' costs may be reduced through this or other conservation programs, the cost estimates and adjustments discussed in this report will be an overestimate.

Our analyses focused on land application of manure and the costs that animal producers might face in meeting nutrient application standards. Our findings have identified several issues that will require additional research, and indicated potential options for reducing the costs of meeting environmental goals.

- *Crop producers' willingness to accept manure is a very important determinant of manure-spreading costs.* A number of factors impede greater use of manure, including uncertain nutrient content, soil compaction associated with heavy manure application machinery, and odor. Research on how these impediments might be overcome, education on the benefits of using manure, and financial assistance for crop farmers using more manure could reduce farmers' manure management costs.
- *Advances in feed management in the near future may increase the options available to livestock and poultry producers for reducing nutrients in manure.* Further economic analyses could indicate the potential for such advances to reduce overall manure management costs, and how the use of such feed management options might be encouraged. We found that one such option, phytase in hog feed to reduce phosphorus concentrations, could reduce manure management costs for large hog farms under a phosphorus-based standard by up to 20 percent.
- *The costs of complying with manure management requirements could instigate structural and geographical shifts in the livestock and poultry sectors.* Our analysis indicates that the highest per-unit costs for meeting a nutrient standard are often borne by the largest operations. Sectors such as swine and poultry have seen a significant move toward integration, the use of production contracts, and larger farms, primarily because of the efficiencies these structural changes bring. The impacts of manure management costs on the potential benefits from this structure could influence whether such trends continue, whether smaller operations (non-CAFOs) not affected by current regulations become more competitive, and the degree to which location will be considered in expansion decisions.