Importance of Cost Offsets for Dairy Farms Meeting a Nutrient Application Standard

Marc Ribaudo and Jean Agapoff

The U.S. Environmental Protection Agency requires concentrated animal feeding operations to develop and implement a comprehensive nutrient management plan. Changes in manure management to meet nutrient application standards will generally increase production costs. Some of these costs can be offset by savings from replacing commercial fertilizer with manure nutrients, and through financial assistance programs such as the U.S. Department of Agriculture's Environmental Quality Incentives Program (EQIP). A manure application cost model was used to examine the costs to confined dairy farms of meeting nutrient application standards, and the ability of fertilizer offsets and EQIP to reduce these costs.

Key Words: animal feeding operations, Environmental Quality Incentive Program, dairy, manure nutrients

Livestock and poultry manure can provide valuable organic material and nutrients for crop and pasture growth. However, nutrients contained in animal manure can degrade water quality if they are over applied to land and enter water resources. The nutrients of greatest water quality concern are nitrogen and phosphorus. Both can promote excessive algal growth that degrades ecosystem health. Nitrogen (in the form of nitrate) is also a human health concern in drinking water. Animal waste is a source of both.

Animal waste has become a major focal point of environmental policy. A shift in the livestock and poultry industry over the past several decades towards fewer, larger, spatially concentrated operations has prompted concerns over the utilization and disposal of animal waste. In response to increased environmental concerns over livestock and poultry production, the U.S. Environmental Protection Agency (EPA) introduced new regulations in 2003 for concentrated animal feeding operations (CAFOs) under the Clean Water Act. A dairy can be defined as a CAFO if it has more than 700 mature dairy cattle, or between 200 and 699 mature dairy cattle when it directly discharges wastewater to surface water or the animals come into contact with surface water. One of the changes is to require CAFOs applying manure to land to meet nutrient application standards defined by an approved nutrient management plan (EPA 2003). This is the first time that land application of nutrients is being regulated as a point source. In addition, the U.S. Department of Agriculture is encouraging the voluntary adoption of nutrient management plans by all animal feeding operations (AFOs) (NRCS 1999b). The goal is that all animal feeding operations be covered by a nutrient management plan in 10 years. To assist farmers meet environmental goals, Congress mandated that 60 percent of the available funding under the Environmental Quality Incentives Program be earmarked for conservation concerns on animal operations.

Developing and implementing a nutrient management plan imposes costs on producers, including plan development, soil testing, manure nutrient testing, manure hauling and application, and recordkeeping. Land application of manure to meet a nutrient standard may be particularly costly if large amounts of additional land are needed to prevent over-application of nutrients and if manure must be hauled off the farm (Ribaudo et al. 2003). These costs affect producers' bottom lines.

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Costs can be reduced through two types of offsets (Ribaudo, Catanneo, and Agapoff 2004). A commercial fertilizer offset occurs when manure has been over applied on some cropland and when meeting a nutrient application standard results in an excess of manure nutrients that can then be applied on additional cropland. Manure nutrients can replace commercial fertilizer on the additional land, reducing commercial fertilizer costs. A second potential source of cost offset is USDA's Environmental Quality Incentive Program (EQIP). EQIP offers financial assistance for several conservation practices that help farmers utilize manure more efficiently. In this paper we assess the costs to dairy operations of meeting nutrient standards and the potential for offsets to defray these costs. We focus on dairy primarily because of the availability of a farm-level survey. The degree to which dairy farmers can offset the costs of nutrient management will indicate the cost of meeting EPA regulations for CAFOs, and whether nutrient management is a viable practice for non-regulated dairy farms.

Dairy Sector and Nutrients

In 1982, the Census of Agriculture indicated that there were 161,563 farms with confined dairy in the United States, totaling 9.9 million animals (ERS 2002a). By 1997, the number of dairy farms had shrunk to 86,354 (down 47 percent), while the number of dairy cows had decreased only 13 percent (ERS 2002a), resulting in many more cows on larger facilities. An estimated 22 percent of the recoverable nitrogen (nitrogen remaining after losses during collection and storage) in dairy manure and 34 percent of the recoverable phosphorus was in excess of crop nutrient needs at the farm level in 1997 (Gollehon et al. 2001). Excess nutrients are prone to leave the field and pollute water resources.

EQIP and Manure Management

The Environmental Quality Incentive Program provides technical assistance, cost-share payments, and incentive payments to operators of working farms for implementing conservation practices. EQIP was introduced in the 1996 Federal Agriculture Improvement and Reform Act and amended by the 2002 Farm Security and Rural Investment Act. The program is managed by the USDA's Natural Resource Conservation Service (NRCS). Assistance can be in the form of a cost-share payment (percentage of implementation cost) or incentive payment (per-acre payment based on activity). Animal feeding operations can receive financial assistance for waste management structures and various waste management handling and application practices. Contracts for financial assistance are for 1 to 10 years, with a maximum of $450,000 per farm over FY2002–2007 (ERS 2002b). EQIP was funded at about $200 million per year from 1996 through 2000. Funding is authorized to increase incrementally from $400 million in 2002 to $1.3 billion in 2007. All farmers are eligible for EQIP. Prior to 2002, large animal operations were ineligible for EQIP funds. This was changed in 2002 to assist large operations to meet EPA's regulations. Sixty percent of EQIP funds are earmarked for resource issues on animal operations.

The specific practices farmers can use to help them meet manure nutrient standards include the following:

Nutrient management. Nutrient management involves managing the amount, source, placement, form, and timing of the application of nutrients and soil amendments (NRCS 1999a). One of its purposes is to "properly utilize manure or organic by-products as a plant nutrient source" (NRCS 1999a, p. 1). A payment is made on a per-acre basis for developing and implementing a nutrient management plan. Activities covered by this practice include the development of the plan by a certified specialist, soil testing, plant tissue testing, nutrient application timing, nutrient application rates, field risk assessment, and heavy metals monitoring.

Waste utilization. "Waste utilization" is using agricultural wastes, such as manure and wastewater from livestock and poultry operations, as a nutrient source and to improve soil tilth (NRCS 2001). The payment is on a per-acre basis for lands on the dairy farm receiving waste in an approved manner, and is intended to cover the development of a waste management plan, the application of waste according to that plan, and recordkeeping. Where wastes are utilized to provide nutrients to crops, the "nutrient management" practice must also be followed.

Manure transfer. Manure transfer refers to a conveyance system using structures, conduits, or equipment for moving manure (NRCS 1997a). The purpose of manure transfer is to transfer animal manure to a manure storage/treatment facility, a loading area, or to agricultural land for final utilization. Manure transfer is part of a planned agricultural manure management system. Payment for manure transfer is a percentage of the cost for manure moved off the farm. Other EQIP-supported practices that might complement manure nutrient management, such as soil erosion control, fencing, vegetative buffers, and manure storage handling structures, are not considered in this paper.

Nutrient Application Standards

We based our manure nutrient application standards on NRCS nutrient management policy. The CAFO final rule states that permitting authorities may use the NRCS Nutrient Management Conservation Practice Standard as guidance for developing applicable nutrient application standards (EPA 2003). Nutrient management criteria are established by the NRCS conservation practice standard to provide adequate nutrients for crop growth and to minimize the potential for adverse environmental effects (NRCS 1999a). The primary criterion established by NRCS is that land application rates for nutrients be based upon land grant university nutrient application recommendations.

A nutrient application standard can be either nitrogen (N) based or phosphorus (P) based. A manure application rate based on a nitrogen standard supplies all the nitrogen needed by crops, but it also generally over-applies phosphorus. The ratio of phosphorus to nitrogen in manure is generally higher than the ratio of phosphorus to nitrogen that crops require to grow (Mullins 2000). NRCS policy permits use of the nitrogen standard on sites for which supplemental phosphorus is recommended, or when a risk assessment tool has determined that the risk for off-site transport of phosphorus is acceptable. [The Phosphorus Index is currently the most widely used risk assessment tool for this purpose (Lemunyon and Gilbert 1993)]. Otherwise, the P standard must be followed. Following a P standard often requires supplemental nitrogen from commercial fertilizer.

What the Literature Says About Manure Use as a Nutrient Source

The literature suggests that animal feeding operations might treat manure as a waste rather than a source of nutrients, and therefore over apply it to land primarily as a means of disposal. Henry and Seagraves (1960) presented the basic economics of hauling and spreading animal waste on land. They recognized the potential environmental problems from poultry litter as that sector was moving toward larger production facilities. The two most important factors that determine the net value of manure are its nutrient content and the distance it needs to be hauled before it is used. Nutrient content enhances manure's value, while transportation distance reduces it. The authors concluded that the unprofitability of moving litter long distances (because of an unfavorable weight-to-nutrient ratio) leads to over-application on land near the production houses. With application rates that exceed crop needs, the value of manure drops because crops cannot utilize the extra nutrients.

Roka and Hoag (1996) looked for evidence that swine producers factor the value of manure into their livestock management decisions. In their estimation, a farmer makes three decisions that affect the on-farm value of manure: choice of a treatment system, choice of area receiving effluent, and choice of crops grown. The authors found that the value of pork dominates a producer's hog production decisions, and that producers are relatively insensitive to the value of manure. Under the most favorable conditions, their estimated manure value is negative (-$2.94/head). Production cycles or other management options were not changed to increase manure's value. Manure's negative value may prompt farmers to view it as a waste rather than a resource, leading to over-application on land nearest the production facility.

Feinerman, Bosch, and Pease (2004) studied manure demand for crop nutrient application under alternative regulatory standards. Model estimates for Virginia found that manure nutrient standards greatly reduce excess nitrogen and phosphorus, but with a 5 to 15 percent reduction in economic welfare to the farm (excluding environmental benefits).

Innes (2000) developed a conceptual model of livestock/poultry production and regulation to illuminate the issues of manure generation and management. The model represents the waste management decisions of private animal producers, manure impacts on the environment, the effect of market forces, and implications for the design of efficient government regulatory policies. The model includes spills from animal waste storage (lagoons), nutrient leaching and runoff from fields, and direct ambient pollution from animal operations, including odors, pests, and ammonia gases.

Innes used the model to evaluate how various regulations on animal production affect economic efficiency, and found that the externalities associated with animal production (e.g., water and air pollution) result in too many large facilities that are also inefficiently large. Innes contends that when manure applications are not regulated, producers will always choose to spread more manure nutrients to nearby cropland than crops can use. In this instance, regulating observable producer choices that affect manure-spreading practices might enhance economic efficiency.

Estimating the Costs of Meeting Nutrient Standards

We used a simulation model developed by Fleming, Babcock, and Wang (1998) (hereafter referred to as the Fleming model) to estimate the cost and benefit of meeting a nutrient application standard on dairy farms. In the interest of space we do not present a detailed description of the model, as it is fully described elsewhere (Fleming, Babcock, and Wang 1998; Ribaudo et al. 2003). In simple terms, the model has two components. The first estimates the cost of transporting and spreading manure to a specific amount of receiving land, the second estimates benefits from replacing commercial fertilizer with manure nutrients (described below).

Cost is based on the distance manure is hauled, the amount of land covered, and whether additional commercial fertilizer is required to meet plant needs. The model assumes the farm is in the center of potential "spreadable" land. The model contains an algorithm for estimating the distance manure must be hauled from the farm to reach the desired amount of land, given that some portion of land is not available for receiving manure.[1] Some land is in uses other than crop or pasture. Some cropland is in crops unsuitable for receiving manure (we assume that vegetable crops do not receive manure). Some landowners with suitable land may be unwilling to use manure. There are several potential drawbacks to land application of manure that could discourage its use. These factors include uncertainty associated with manure nutrient content and availability, high transportation and handling costs relative to commercial fertilizer, soil compaction from spreading equipment, dispersion of weed seeds, concerns for added regulatory oversight, and public perception regarding odor and pathogen issues (Risse et al. 2001). It is also less likely that a farm with animals would accept manure from another farm because of concerns about disease.

To fully estimate the costs of EPA's regulation, we added the costs of developing and implementing a nutrient management plan (recordkeeping, soil testing, manure testing, and plan development). We assumed that plan development costs were the same whether an N-based plan or a P-based plan, and that both N and P would be tested regardless of the plan. We did not consider a mixed plan that contains both N-based and P-based application rates.

The important pieces of information needed for the Fleming model include the amount of manure produced on the farm, its nitrogen and phosphorus content, amount of cropland on the farm, the crops grown and their nutrient uptake, land use off the farm, landowner willingness to accept manure (WTAM), hauling and application costs, and the costs associated with developing and implementing a nutrient management plan. We used data from the 2000 dairy Agricultural Resource Management Survey (ARMS) to obtain farm-level data on operation size, manure storage technology, manure application technology, land used for spreading manure, cropland base, and crop yields for farms with confined dairy cows. The ARMS survey obtained more than 870 responses from dairy farms with 10 or more milk cows from 22 states. The survey sample represents about 90 percent of U.S. milk production in 2000. Land use data for land in the county in which the farm was located were obtained from the 1997 National Resources Inventory (NRCS 1997b). Manure nutrients available for crops after losses in storage and applications were calculated using the

[1] To the extent that land use off the farm is not distributed evenly but clustered, the costs of hauling manure may be overestimated.

procedures outlined in Kellogg et al. (2000), taking into account the storage and handling technologies reported in the survey. Charges for hauling and applying manure and for commercial fertilizer reflect those used by custom applicators. We assumed that time and equipment would be the same for farmers applying manure themselves. Costs for developing and implementing a nutrient management plan were obtained from NRCS.

We divided the sample into two regions, North and South (Figure 1). We looked at three size classes based on EPA's definitions: small (< 200 mature dairy cows), medium (200–699 mature dairy cows), and large (≥ 700 mature dairy cows). Large operations are CAFOs under the new Clean Water Act regulations, and must meet nutrient application standards. Smaller operations can also be designated as CAFOs on a case-by-case basis if they discharge directly into a stream. How many operations would be so designated could not be determined, *a priori*.

To estimate the gross costs of meeting a nutrient standard (cost without offsets), we first estimated a pre-regulation baseline cost of spreading manure with the Fleming model, using the acreage reported in the survey as having actually received manure. We then estimated the cost of applying manure to the land required by an N- or P-based standard. Calculating the maximum permissible nutrient application rate for each farm starts with the nutrients contained in the harvested portion of the crops grown. The amount of nitrogen (N) or phosphorus (P) removed by harvest for each of 24 crops was calculated using an average nutrient content per unit of crop output and the crop yields, as outlined in Kellogg et al. (2000).

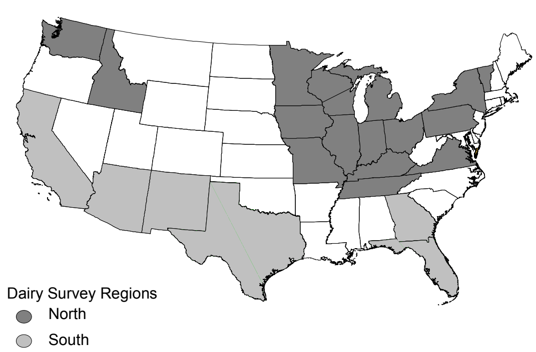

Figure 1. Dairy Production Regions

The amount of P removed by harvest becomes the on-farm P application standard that dairy farms are assumed to meet. To account for unavoidable losses in the soil that make some nitrogen unavailable to plants, a "nutrient recommendation" was calculated by multiplying nitrogen removed in harvest by 1.43 (Kellogg et al. 2000). This becomes the on-farm N application standard.

We assumed that manure would first be applied to land on the farm. If additional land was needed, it would be hauled to the nearest surrounding land in the county that was both acceptable for receiving manure and willing to use it. We assumed that the dairy operator pays all the costs associated with moving manure off the farm: soil testing for receiving acres, transportation, and application. The difference between the cost of spreading on required acreage to meet the regulation and the cost of spreading on baseline acreage is the cost of meeting the nutrient standard, without offsets. Our analysis does not consider the costs that may be incurred by changing manure handling technology, storage, labor, or other organizational factors that could be taken to meet a nutrient standard.

When land requirements were compared with the amount of land reported as having received manure, we found that most large and medium farms were not spreading it on enough land to meet a nitrogen standard, and few farms were spreading it on enough land to meet a phosphorus standard (Table 1). Farms not spreading manure on enough land would incur additional hauling and application costs in order to meet a nutrient application standard. Most small dairy farms (90 percent) have enough land to meet an N-standard, but only about a quarter of large farms do. A majority of small farms (65 percent) still have enough land to meet a P standard, but few medium (18 percent) or large farms (2 percent) do. Farms needing to move manure off the farm could incur substantial hauling costs to reach enough suitable land, more so than if they had enough land of their own. Small and medium farms in the North generally have more land available per animal than similar-sized farms in the South. For example, while 90 percent of small farms in the North have enough land to meet an N standard, only 33 percent of small farms in the South do.

Table 1. Percentage of Dairy Farms Meeting N-based and P-based Application Standards, by Region and Size, 2000

Region and size (cows)	Farms meeting N-based standard	Farms meeting P-based standard	Farms with adequate land for N-based standard	Farms with adequate land for P-based standard
South				
< 200	19.5	4.8	33.2	18.4
200–699	5.7	0	8.5	1.1
≥ 700	21.3	1.0	26.6	2.6
North				
< 200	72.1	27.3	91.2	66.4
200–699	46.4	10.9	86.2	31.6
≥ 700	26.5	0	26.5	0
Nation				
< 200	70.8	26.7	89.8	65.3
200–699	27.5	5.8	39.4	17.5
≥ 700	23.0	0.7	26.6	1.8

Source: 2000 dairy ARMS (Agricultural Resource Management Survey) data.

Estimating Cost Offsets

The fertilizer offset is realized when cropland or pastureland not receiving manure in the baseline receives manure after the nutrient plan is implemented. The benefit component of the Fleming model was used to estimate the fertilizer offset. We assume that spreadable land not receiving manure is receiving commercial fertilizer at agronomic rates. Nutrients in manure applied to fields are valued at the price of the commercial fertilizer they replace. Excess applications of manure nutrients have a zero value because they do not contribute to crop yields. If one nutrient in manure is not sufficient to cover crop needs, then commercial fertilizer must be applied to make up the deficit, and the application cost must be paid.

For additional land on the farm receiving manure, we credited the value of commercial fertilizer replaced by manure as a fertilizer offset, plus the cost of spreading commercial fertilizer if manure provides all the crop nutrient needs. If a manure nutrient was insufficient to meet crop needs, supplemental commercial fertilizer was applied and the cost of the additional fertilizer and applying it was included. For manure moved off the farm, we assumed that the dairy operator received a payment from the crop producer equal to the nutrient value of the manure (equivalent to the costs of the commercial fertilizer being replaced). No benefit was given for manure nutrients applied in excess of crop needs. It is possible that crop producers would receive manure for free. If so, they would receive a windfall offset that we credited to the manure producer. Farmers that were applying manure at an agronomic rate in the baseline would not have to apply manure on any additional land to comply with the regulation, so they would not receive a fertilizer offset. However, they do bear the costs of developing a nutrient management plan, testing, and recordkeeping.

The second offset involves financial assistance from EQIP (ERS 2001). Per-acre EQIP payments for Nutrient Management and Waste Utilization and cost-share rates for Manure Transfer were obtained from 1997–2000 EQIP program data (Table 2). Average payments for Nutrient Management ranged from \$4.35–\$11.51 per acre across survey states. Average per-acre payments for waste utilization ranged from \$4.83–\$10.60 per acre. Farm-level payment calculations for these practices were based on acres of land on the dairy farm receiving manure, and not on land off the farm receiving manure. The EQIP payment rates for the state in which the farm is located were used to estimate farm-level EQIP payments. We used a cost-share rate for manure transfer of 50 percent of the cost of hauling manure on and off

Table 2. Mean EQIP Payments for Nutrient Management and Waste Utilization, by State, 1997–2000

State	Nutrient management	Waste utilization
	$/acre	
Arizona	8.67	7.25
California	8.05	4.85
Florida	9.64	7.96
Georgia	9.64	7.96
Idaho	8.67	7.25
Illinois	7.32	5.50
Indiana	7.32	5.50
Iowa	7.32	5.50
Kentucky	9.82	10.60
Michigan	4.35	4.83
Minnesota	4.35	4.83
Missouri	7.32	5.50
New Mexico	8.67	7.25
New York	6.88	7.49
Ohio	7.32	5.50
Pennsylvania	6.88	7.49
Tennessee	9.82	10.60
Texas	11.51	7.25
Vermont	6.88	7.49
Virginia	9.82	10.60
Washington	8.05	4.85
Wisconsin	4.35	4.83

Source: ERS (2001).

the farm. We assumed that all dairy farmers would receive the maximum EQIP payment they are eligible for. We limited annual payments to each farm to $90,000 in order to model the 5-year program maximum of $450,000 specified in the 2002 Farm Act. Farms receiving manure may also receive EQIP payments, but these were not considered in the analysis.

An example helps show the steps taken to estimate costs and offsets. The average large dairy operation in the South contains 2,066 dairy cows and has 320 acres of spreadable land. Manure produced by its animals is spread on 310 acres of land on the farm. Having to meet a nitrogen (phosphorus) standard would require spreading manure on 661 (2,000) acres of cropland, given the nitrogen (phosphorus) uptake of the crops grown, meaning that 341 (1,680) acres of land off the farm are needed for spreading manure, assuming that the mix of crops is the same as on the farm. Manure would have to be hauled an average of 8 (14) miles to reach enough spreadable land, given the land use in the surrounding county and an assumed landowner willingness to accept manure of 10 percent (manure can be used on only 10 percent of spreadable land). The cost of developing and implementing a nutrient management plan and hauling and applying manure to the additional 351 (1,690) acres is $105,711 ($190,830). The fertilizer offset on the 351 (1,690) acres is $22,970 ($30,758). The maximum EQIP offset for the entire 661 (2,000) acres receiving manure is $68,143 ($79,589).

Results

The estimated gross cost of meeting a nitrogen-based nutrient application standard ranges from about $1,700 per small farm in the North to over $105,000 per large farm in the South, assuming a WTAM of 10 percent (Table 3). Differences in costs reflect the amount of land available on the operation for spreading manure and the percentage of land off the farm that can be used for spreading.

Fertilizer offsets cover a portion of the costs of meeting a nitrogen standard, but results suggest that adopting a nutrient management plan does not pay for itself for any size dairy in any region. Operations that are already spreading on enough land to meet a standard do not realize any fertilizer offset because no commercial fertilizer is displaced due to the policy (e.g., many small farms in the North). Farms that must spread manure on the most additional land would receive the greatest fertilizer offset (generally large farms), but fertilizer offsets do not cover nutrient plan development and implementation costs. On average, fertilizer offsets covered about 22 percent of the costs of meeting the standard on large dairies that must implement nutrient management plans under the Clean Water Act.

Comparing the net cost of meeting the nitrogen application standard (cost minus fertilizer offset) with total baseline production costs (variable costs and allocated overhead) gives some indication of the impact of the standard on a farm's economic performance (Figure 2). Meeting the

Table 3. Costs of Meeting a Nutrient Standard, by Operation Size, Region, and Willingness to Accept Manure

Region and size (cows)	Cost of meeting a nutrient standard	Fertilizer offset	Potential EQIP payment	Potential net cost	Cost of meeting a nutrient standard	Fertilizer offset	Potential EQIP payment	Potential net cost
	10 percent willingness to accept manure							
	$/farm							
South								
< 200	9,371	2,316	10,298	-3,243	12,690	2,774	12,079	-2,163
200–699	44,443	8,817	42,637	-7,011	67,881	10,985	49,720	7,176
≥ 700	105,711	22,970	68,143	14,598	190,830	30,758	79,589	80,483
North								
< 200	1,715	60	7,777	-6,122	2,593	271	8,831	-6,509
200–699	25,848	2,502	40,360	-17,014	41,869	3,999	48,132	-10,262
≥ 700	83,888	18,110	72,343	-6,565	162,367	26,796	89,336	46,235
	40 percent willingness to accept manure							
	$/farm							
South								
< 200	4,380	2,316	8,366	-6,302	6,030	2,774	9,253	-5,997
200–699	0,010	,817	3,486	-22,283	31,826	10,985	39,181	-18,340
≥ 700	7,384	2,970	8,164	-33,750	90,130	30,758	67,483	-8,111
North								
< 200	18	0	,369	-6,511	1,332	271	8,200	-7,139
200–699	0,867	,502	3,738	-25,373	18,916	3,999	38,747	-23,830
≥ 700	4,536	8,110	61,036	44,610	73,980	26,796	73,792	-26,608
	80 percent willingness to accept manure							
	$/farm							
South								
< 200	3,004	2,316	7,789	-7,101	4,133	2,774	8,351	-6,992
200–699	12,870	8,817	29,913	-25,860	21,228	10,985	34,048	-23,805
≥ 700	30,326	22,970	54,773	-47,417	60,699	30,758	62,050	-32,109
North								
< 200	726	60	7,272	-6,606	982	271	8,025	-7,314
200–699	6,618	2,502	31,710	-27,594	12,213	3,999	35,853	-27,639
≥ 700	20,114	18,110	57,767	-52,763	48,000	26,796	67,440	-46,236

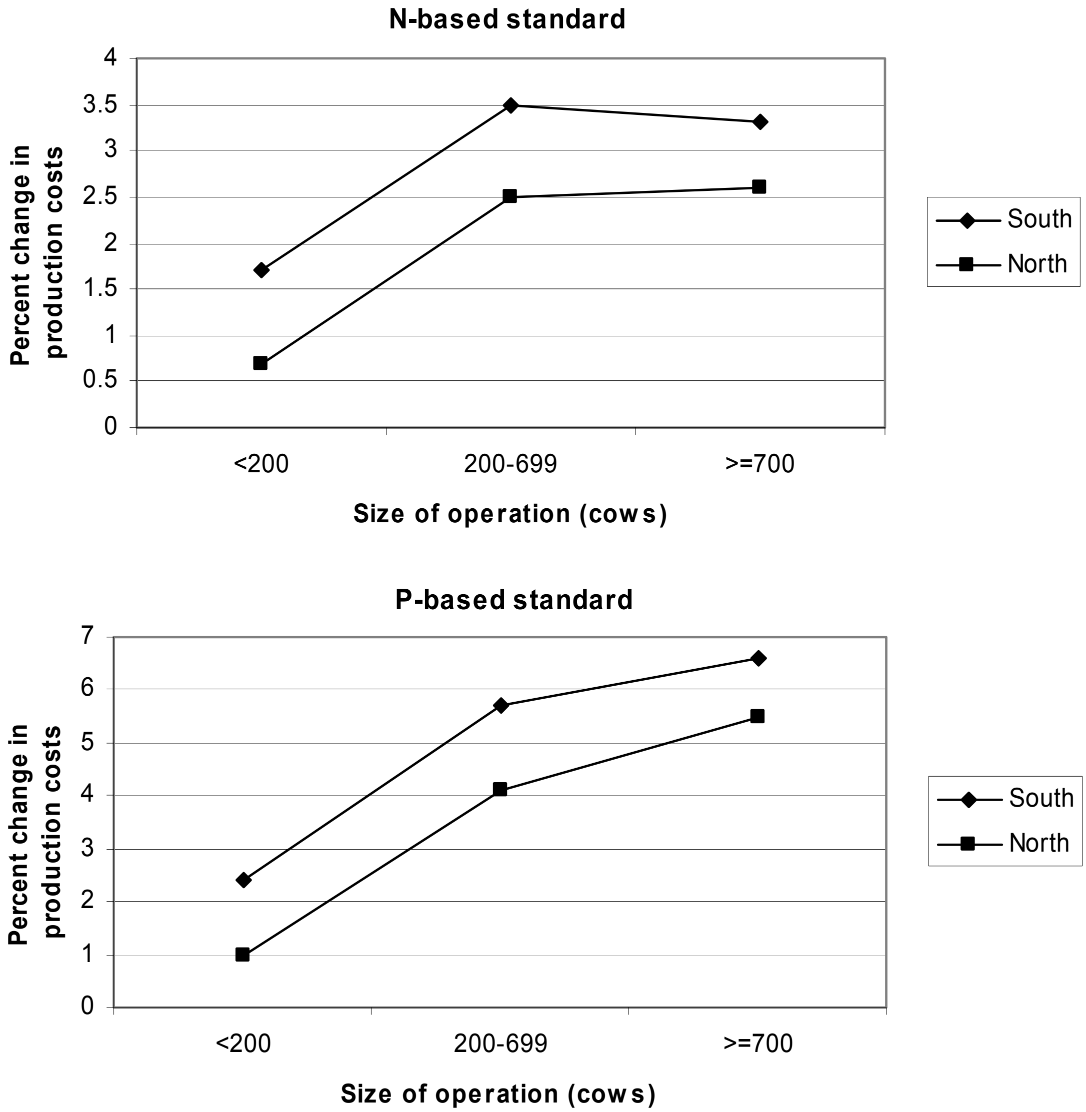

Figure 2. Cost of Meeting Nutrient Standard as Percentage of Production Costs, by Size Class and Region, Assuming Willingness to Accept Manure of 10 Percent

nitrogen standard increases production costs for large dairies between 2.5 percent (North) and 3.3 percent (South), assuming a WTAM of 10 percent. The impact on medium-sized operations is about the same. Small operations would experience much smaller cost increases (between 0.5 and 1.7 percent). Over 70 percent of small operations were already spreading on enough land to meet a nitrogen standard, and the only additional costs for these farms were those associated with developing a nitrogen plan, soil testing, and recordkeeping.

Meeting a more stringent phosphorus-based standard increases the costs for most farms (Table 3). With a lower manure application rate required to meet a phosphorus standard, a larger land base is needed for spreading. This results in generally more manure having to be moved off the farm. Costs increase most for large farms, where the average cost is about twice that of meeting the N-standard. Fertilizer offsets are also higher because manure nutrients are applied on a larger land base and no nutrients are applied in excess (unlike under an N-based standard, where P is usually in excess of plant needs). However, the additional fertilizer offsets are insufficient to cover the additional hauling and spreading costs, so the increase in production costs is greater than under the N-based standard. Production costs for large dairies under the P standard were estimated to increase between 5.5 and 6.7 percent above the baseline assuming a WTAM of 10 percent, compared to 2.4 to 3.2 percent under the N standard (Figure 2).

Financial assistance from EQIP is a significant economic benefit to animal operations that receive it. Estimated EQIP payments more than cover the full costs of meeting the nitrogen standard for most dairy farms with a WTAM of 10 percent (after accounting for the fertilizer offset). Large farms in the South are the only ones that still bear a net cost after receiving the maximum EQIP payment, on average. There are three reasons why EQIP payments can exceed the net cost of implementing a nutrient management plan. One is that the cost of meeting the standard is calculated as the change in cost from the baseline costs, while EQIP payments are based on total manure spreading and handling costs, including those on baseline acres. Second, payments for nutrient management and waste utilization are incentive payments that are not based directly on implementation costs (as a cost-share payment would be). Incentive payments could be greater than the actual cost to a farm of implementing a practice. Average EQIP payments for large farms ranged between $68,143 and $72,343 per year (Table 3). Third, EQIP payments do not consider potential fertilizer offsets.

Because more manure must be transported off the farm, and for longer distances, potential EQIP payments could be about 18 percent greater under the P-based standard than under the N-standard. Fertilizer and EQIP offsets could cover the costs of meeting a P standard for fewer farms than for meeting an N standard. Large and medium farms in the South and large farms in the North would face higher production costs even with the EQIP offset.

Willingness to accept manure has important implications for the costs of meeting a nutrient application standard. A higher WTAM reduces the cost of moving manure off the farm by reducing the distance that manure must be hauled to reach spreadable land (Table 3). Increasing WTAM from 10 percent to 40 percent reduces the cost of meeting a nitrogen standard significantly for most operations, particularly those that have to move large amounts of manure off the farm. For example, additional costs on large farms in the South are 55 percent lower if WTAM is 40 percent rather than 10 percent. Potential EQIP offsets would fall by about 15 percent overall because of reduced hauling costs, but the acreage-based payments are unaffected since acres receiving manure remain the same. Fertilizer and EQIP offsets are sufficient to cover the costs of meeting either an N-based or P-based nutrient application standard for all farms when WTAM is 40 percent. Further increasing WTAM to 80 percent reduces hauling costs even more.

However, increasing WTAM did not result in fertilizer offsets being sufficient to overcome the costs of developing and implementing a nutrient management plan for any farm studied. Farmers were unable to completely cover the additional costs without financial assistance from EQIP.

Implications for Policy

Meeting nutrient application standards increases the production costs of large dairies designated as CAFOs by the Clean Water Act. Fertilizer offsets can mitigate some of these costs, but likely not all. Production costs increase under all scenarios examined unless additional cost offsets such as financial assistance through EQIP are received. Whether EQIP can cover all nutrient plan implementation costs depends on the type of standard, farm characteristics, and the willingness of other land owners to accept manure. We assumed that dairy farms would receive the maximum EQIP payment. Whether an individual farm receives the maximum depends on the EQIP budget relative to total demand, and the ranking of the farm's application for funds relative to other applications.

EQIP contracts for nutrient management are generally for 4 years. Some large farms might consider additional adjustments in production practices, changes in farm size, or relocation to an area where land is more readily available for spreading manure when EQIP payments end or if budget considerations greatly reduce potential payment rates.

Smaller operations, expected to adopt nutrient management plans voluntarily, may not be willing to do so without financial assistance. Fertilizer offsets alone were not estimated to be sufficient to cover the costs of implementing a nutrient management plan. However, EQIP was estimated to be able to cover costs in most scenarios. Nutrient management is unlikely to become profitable over the long term without changes to reduce the overall costs so that there is no loss in net returns even without financial assistance.

This analysis does not consider potential changes in milk production and prices that might result from an increase in production costs. Since the CAFO regulations are national in scope, impacts on dairy prices are possible (Ribaudo et al. 2003). If higher manure management costs increase prices, less financial assistance from EQIP might be needed to cover the higher production costs because of price offsets (Johansson and Kaplan 2004).

The results suggest that costs could be greatly reduced if more crop producers were willing to use manure as a nutrient source. Increasing willingness to accept manure greatly reduced manure management costs for dairies meeting a nutrient application standard. The results suggest that a potentially effective approach for assisting dairies and other livestock and poultry operations in meeting a nutrient application standard would be to provide education, technical assistance, and financial assistance to potential users of manure nutrients, and to support the development of community-based programs for fostering cooperation between animal producers and crop producers. While increasing the use of manure off the farm might not make fertilizer offsets sufficient to cover increased manure management costs, it would greatly reduce costs.

Another potential solution to the land application problem, which this paper does not address, is alternative strategies for handling manure. Advanced feed management for reducing N and P in manure could reduce the amount of land needed for spreading manure. Solid-liquid separation or manure drying could reduce the weight of the material needing disposal, reducing hauling costs. Planting crops that absorb high amounts of nutrients would reduce the amount of land needed for spreading manure. Manure might also be used as an input for a higher-value product, such as energy, fertilizer, or compost. Whether these approaches are economically feasible depends on their costs relative to land application.

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