Chapter 5—National Analysis: Industry Effects of Manure Management

Changes in manure management will likely have broader effects than those captured in farm-level and regional analyses. In this chapter, we examine changes in the livestock and poultry sectors throughout the United States that would result from the adoption of nutrient standards by animal feeding operations. Adherence to a nutrient application standard by all AFOs, or even just the largest, is likely to affect the prices received by producers and prices paid by consumers. How would prices for crops and livestock/poultry products be affected by nutrient standards? How would the spatial distribution of agricultural sectors change under nutrient standards? And how much would nutrient standards reduce the amount of manure nutrients produced across the Nation?

The farm-level and regional analyses demonstrated that nutrient standards are likely to increase the cost of production for those operations required to adhere to them. The magnitude of these cost increases depends on a number of factors, including the amount of manure that would require transporting off the farm, the availability of cropland for the application of manure nutrients, and the willingness of cropland operators to substitute manure nutrients for commercial fertilizer. Increased production costs in the animal sector could be transferred through supply and demand interactions to livestock and poultry producers, cropland operators, and consumers (see Appendix 5-A, "Market Interaction Primer," for a graphical presentation of these interactions).

We use the U.S. Regional Agricultural Sector Model (USMP) to investigate several possible scenarios for the adoption of nutrient standards by livestock and poultry producers in the United States (see appendix 2 in Claassen et al., 2001). The USMP is a spatial and market equilibrium model designed for general-purpose economic and policy analysis of the U.S. agricultural sector. The economic units analyzed within USMP include products, inputs, geographic areas, and supply/demand markets.

We modify the basic model to evaluate how equilibrium conditions will change in response to nutrient application standards. First, we calculate the generation of livestock and poultry manure nutrients by region and species. The base costs and mileage costs to transport this manure to available cropland are endogenously determined using the Fleming et al. (1998) formulation in conjunction with regional and species-specific cost coefficients from the literature (Borton et al., 1995; Pease et al., 2001). The costs to develop a nutrient management plan, for periodic testing of manure nutrient composition, and for periodic testing of soil nutrient content are also included using USDA estimates (USDA, NRCS, 2003). Furthermore, using current market values for commercial nitrogen and phosphorus, we calculate the savings from substituting manure nutrients for commercial fertilizers. The costs of using manure nutrients are assumed to be covered by the livestock sectors. The savings to cropping enterprises are then incorporated into the regional cropping acreage activities.

The nutrient constraints are chosen to represent likely policy scenarios. Essentially, the adoption of manure-nutrient application standards forces manure production and crop production within a geographic area to be in balance. That is, the aggregate generation of affected manure nutrients in a region is constrained to be no greater than the agronomic nutrient demands of accepting cropland, with no allowance for noncrop use. Manure generation is calculated according to Kellogg et al. (2000) and crop nutrient demands are calculated using the Environmental Policy Integrated Climate Model (EPIC; Mitchell et al., 1998). A region is out of balance if it has more (or less) manure nutrients than can be assimilated by available cropland.

Several changes can occur within the model to allow a region to return to balance. If demand for nutrients is in excess of manure nutrients, commercial fertilizer makes up the difference. If manure nutrients exceed demand, the composition of cropping or livestock/poultry production could change to alter the amount of manure nutrients demanded or supplied. For example, broilers produce manure with higher phosphorus-to-nitrogen ratio than do dairy cows. A region that is generating excess phosphorus relative to the plant needs on manure-receiving cropland could reduce broiler production and increase dairy production. Similarly, different crops utilize nutrients at different rates. For example, hay utilizes more phosphorus than corn, so a region that is generating excess phosphorus could substitute hay acres for corn. The model finds the combination of crop and animal

changes across the regions that minimize the net cost to society.

We use this model to evaluate the implementation of nutrient standards by animal feeding operations defined by EPA as CAFOs on the basis of size (CAFO scenario) and by all animal feeding operations (AFO scenario). EPA regulations directly affect only CAFOs. We evaluate the implications of all AFOs meeting a nutrient standard because that is the long-term goal of USDA. While the adoption of nutrient management practices for non-CAFOs would be voluntary, the AFO scenarios indicate of how much the poultry and livestock sectors might gain or lose by such a change.

We evaluate the impacts on the animal sector across a range of assumptions about the willingness of cropland operators to substitute manure nutrients for commercial fertilizer, paralleling the willingness-to-accept-manure (WTAM) assumptions used in the previous analyses (see box, "Willingness to Accept Manure," p. 21). However, because the national analysis cannot replicate farm-level decisions, we represent WTAM differently here. We define WTAM as the percentage of a region's agronomic demand for nitrogen and phosphorus (based upon crop requirements in that region) that is met by manure nutrients. In other words, as the willingness of cropland operators to accept manure nutrients increases, so does the percentage of each region's nutrient demand that is met by substituting manure nutrients for commercial fertilizers. Therefore, throughout this chapter we will refer to "willingness-to-substitute" rates, or simply substitution rates.

Currently, cropland operators supplement commercial fertilizer with manure as part of their crop fertilization regime on 17 percent of corn acreage and 2-9 percent of soybean acreage (most commonly grown crops) (USDA, ERS 2000a, p. 36). It is unclear to what extent these rates would change as nutrient standards become more integral in livestock and poultry production. We consider four scenarios based on the rate at which manure nutrients are substituted for commercial fertilizer on cultivated crops in each region: 20 percent, 30 percent, 40 percent, and 80 percent. These are compared with the baseline case of no standards/no substitution. The results from these scenarios are compared with the USDA 2010 baseline, when it is assumed that the agricultural sector will have fully adjusted to the adoption of nutrient standards.

Unlike the preceding chapters, we evaluate only a single nutrient standard in this chapter. Because each region in the model is large, there is sufficient land to assimilate manure nitrogen at all of the substitution rates, leaving production decisions for the most part unchanged. However, in many cases, the constraint that manure phosphorus generation be no greater than agronomic phosphorus demand was binding. Therefore, while we impose a nitrogen and phosphorus application standard, the changes resulting from our policy scenarios are for the most part driven by the phosphorus constraint.

Manure Nutrient Restrictions at the National Level

The eight scenarios that we examine (CAFO20, CAFO30, CAFO40, CAFO80, AFO20, AFO30, AFO40, and AFO80) correspond to which livestock and poultry operations adopt manure application constraints (e.g., just CAFOs or all AFOs) and the degree to which cropland operators substitute manure nutrients for commercial fertilizers (20, 30, 40, or 80 percent). As noted earlier, new water quality regulations require that the largest livestock and poultry facilities meet manure nutrient application standards, and the current rates of manure nutrient substitution average between 10 and 20 percent. Therefore, we might expect the CAFO20 scenario to most accurately illustrate the potential changes to the agricultural sector as a response to meeting these nutrient standards without any increases in manure use by cropland operators.

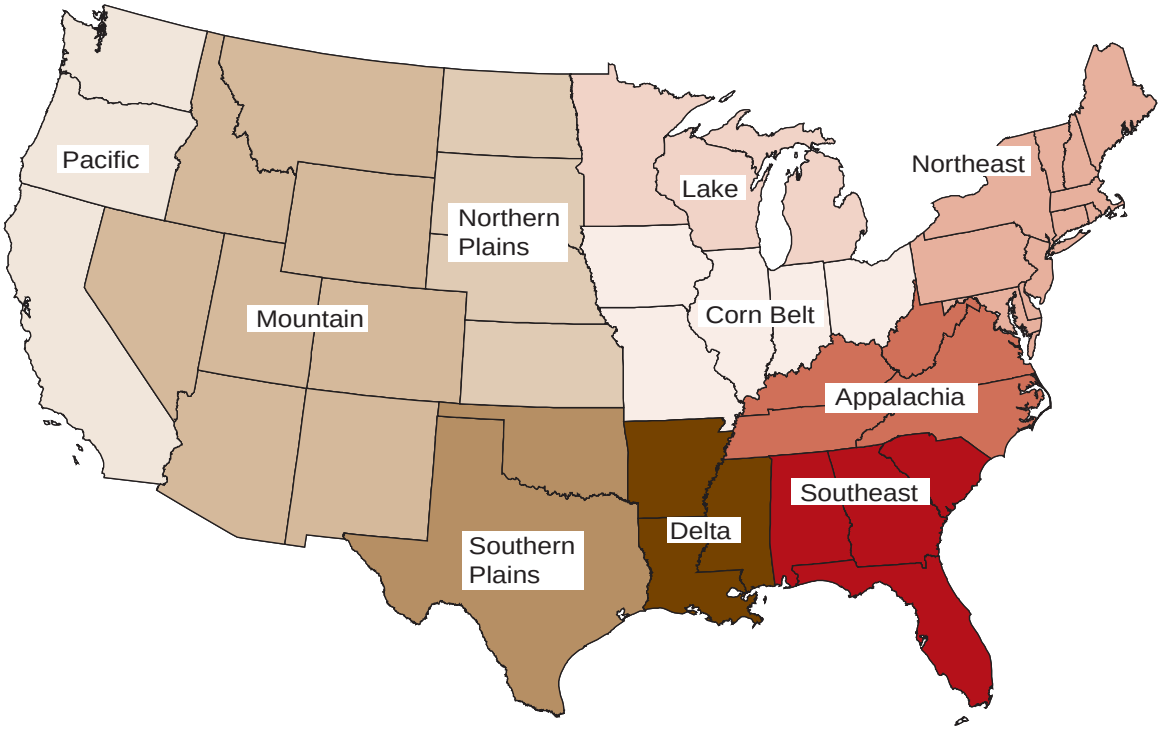
The findings from policy simulations are expressed in terms of changes in animal units produced, crop acreage planted, and costs, savings and net returns across sectors. The national results illustrate the aggregate impacts of these scenarios. For example, CAFOs are only 4.5 percent of the total AFOs in the U.S. (table 5-1). However, the quantity of manure generated by these facilities exceeds 200 million tons, more than 46 percent of the U.S. total and 65 percent of excess nutrients, indicating the substantial differences in the quantities of manure regulated under our CAFO and AFO policies. Disaggregating these results illustrates how the regional cropping, livestock, and poultry sectors may react to manure nutrient standards. Following from our earlier example, the Corn Belt has the greatest number of CAFOs, but those operations generate less than 40 percent of Corn Belt manure. On the other hand, CAFOs generate more than 60 percent of the manure in the Northern Plains, Appalachia, Mountain, and Pacific regions. Clearly, these regions will be affected differently under the various policy scenarios considered. Regional impacts are evaluated across the USDA Farm Production Regions (fig. 5-1).

Table 5-1—Operations with confined livestock/poultry and manure distribution

Region	Operations			Manure generated		
	AFOs	CAFOs	Share of CAFOs	CAFO	AFOs	Share of CAFOs
	Number		*Percent*	*Million tons*		*Percent*
Northeast	31,350	499	1.59	39	6	15.42
Lake	52,498	861	1.64	59	15	25.10
Corn Belt	71,252	2,264	3.18	73	29	39.55
Northern Plains	26,087	1,245	4.77	65	42	64.01
Appalachia	22,776	1,698	7.46	66	41	62.69
Southeast	12,635	1,386	10.97	23	10	43.31
Delta	12,252	917	7.48	19	7	39.04
Southern Plains	10,500	735	7.00	46	18	38.22
Mountain	7,780	656	8.43	33	23	69.31
Pacific	7,654	1,137	14.85	40	24	60.55
Total	254,784	11,398	4.47	462	214	46.36

Source: 1997 U.S. Census of Agriculture (USDA-NASS, 1997).

Figure 5-1
USDA Farm Production Regions



Agricultural Prices and Supplies

Results suggest that animal production in general would decrease with nutrient standards when substitution rates remain at or near current levels (table 5-2). (Those operations in the farm-level analysis with the greatest production cost increases are the most likely to leave the industry.) However, under the CAFO20 and CAFO30 scenarios, these production changes are generally less than 2 percent. Two notable exceptions are production of broilers and turkeys, which fall by more than 7 percent when substitution rates remain at or near current levels. Under both scenarios, there is a slight increase in the production of veal. Under the AFO scenarios, production falls more, especially at the lowest substitution rate. When substitution rates exceed 40 percent, there are essentially no changes in production under the CAFO scenarios and only marginal changes under the AFO scenarios.

With less supply, the prices received by most livestock and poultry producers and those paid by consumers for animal products (milk, eggs, cheese) would increase (table 5-3) when manure-fertilizer substitution remains at or near current levels. Under the CAFO20 and CAFO30 scenarios, most price increases are minimal (less than 2 percent), except for poultry. Price changes would be greatest when all AFOs must meet nutrient standards and the least amount of manure nutrients is substituted for commercial fertilizer. Price changes are negligible when nutrient substitution exceeds 40 percent.

Impacts may spill over into the crop sectors, driven by the demand for land to assimilate manure nutrients and the demand for feed in the more stringent scenarios (tables 5-4 and 5-5). The changes in crop production vary by crop under the various scenarios. However, under the CAFO20 scenario (again, the most "immediate"), acreage planted to corn, barley, and oats falls and production of sorghum, wheat, rice, soybeans, cotton, silage, and hay increases. Most of these changes are small and the net change in total acreage is less than 1 percent. At the lower substitution rates, prices generally fall (with the exception of silage) under both the CAFO and AFO scenarios. At the higher substitution rates, prices generally increase by less than 0.5 percent.

National Net Returns

The analyses in the previous chapters assumed prices remain constant, so the costs of meeting a nutrient standard are borne fully by animal operations. In this analysis, price increases can mitigate some of the implementation costs to operations that remain in pro-

Table 5-2—Change in product supply under manure nutrient standard

Commodity	Baseline quantities	AFO				CAFO			
		20%	30%	40%	80%	20%	30%	40%	80%
	Million	*Percent change*							
Fed beef (Cwt)	149.66	-12.12	-4.39	-1.68	-0.01	-0.51	-0.15	0.00	-0.01
Broilers (Carcass lbs.)	34,942.99	-27.56	-18.55	-9.09	-0.01	-7.57	-1.92	0.00	-0.01
Turkey (Carcass lbs.)	5,950.01	-23.04	-13.97	-8.19	0.00	-7.22	-1.80	0.00	0.00
Manufactured milk (Cwt)	884.62	-3.38	-1.09	-0.48	0.00	-0.54	-0.16	0.00	0.00
Veal (Cwt)	1.34	-2.19	-0.30	-0.01	0.00	0.22	0.07	0.00	0.00
Pork (Cwt)	189.82	-6.61	-2.34	-0.80	0.00	-1.52	0.01	0.00	0.00
Eggs (Dozen)	7,585.81	-1.63	-0.66	-0.32	0.00	-0.35	-0.10	0.00	0.00
Butter (Lbs.)	1,360.34	-5.45	-1.76	-0.78	0.00	-0.87	-0.26	0.00	0.00
American cheese (Lbs.)	2,776.93	-3.35	-1.08	-0.48	0.00	-0.54	-0.16	0.00	0.00
Ice cream (lbs.)	1,193.10	-1.38	-0.45	-0.20	0.00	-0.22	-0.07	0.00	0.00

Table 5-3—Change in product prices

Commodity	Baseline price	AFO				CAFO			
		20%	30%	40%	80%	20%	30%	40%	80%
	Dollars	*Percent change*							
Baseline									
Fed beef (Cwt)	335.42	3.00	1.09	0.42	0.00	0.13	0.04	0.00	0.00
Broilers (Carcass lbs.)	0.36	24.64	7.38	3.62	0.00	3.02	0.76	0.00	0.00
Turkey (Carcass lbs.)	0.39	37.35	14.34	0.06	0.00	5.00	1.25	0.00	0.00
Manufactured milk (Cwt)	11.98	11.12	3.59	1.59	0.00	1.78	0.54	0.00	0.00
Veal (Cwt)	562.61	1.65	0.22	0.01	0.00	-0.16	-0.05	0.00	0.00
Pork (Cwt)	263.00	3.09	1.09	0.37	0.00	0.71	0.00	0.00	0.00
Eggs (Dozen)	0.69	29.10	11.69	5.72	0.01	6.33	1.78	0.00	0.01
Butter (Lbs.)	1.07	19.30	6.23	2.76	0.00	3.09	0.93	0.00	0.00
American cheese (Lbs.)	1.34	9.17	2.96	1.31	0.00	1.47	0.44	0.00	0.00
Ice cream (lbs.)	1.38	11.44	3.69	1.64	0.00	1.83	0.55	0.00	0.00

Table 5-4—Change in crop production

Commodity	Baseline quantities	AFO 20%	AFO 30%	AFO 40%	AFO 80%	CAFO 20%	CAFO 30%	CAFO 40%	CAFO 80%
	Million	*Percent change*							
Corn (Bu)	11,235.38	-2.10	-1.26	-0.60	-0.02	-0.49	-0.11	-0.01	-0.02
Sorghum (Bu)	668.50	10.07	3.01	1.60	-0.07	0.22	0.05	-0.03	-0.07
Barley (Bu)	365.10	3.60	-1.04	-0.06	-0.04	-0.20	0.21	-0.02	-0.04
Oats (Bu)	149.89	-7.25	-5.23	-1.89	-0.03	-1.96	-0.27	-0.01	-0.03
Wheat (Bu)	2,545.09	4.18	1.65	0.81	-0.03	0.35	0.04	-0.02	-0.03
Rice (Cwt)	194.20	16.44	10.16	3.17	-0.11	3.42	1.43	-0.05	-0.11
Soybeans (Bu)	3,245.04	3.52	1.71	0.75	-0.04	0.82	0.09	-0.01	-0.04
Cotton (Bale)	17.50	2.11	1.04	0.48	-0.01	0.25	0.07	-0.01	-0.01
Silage (Ton)	95.60	3.89	1.42	0.72	-0.01	0.66	0.14	0.00	-0.01
Hay (Ton)	155.60	7.48	2.40	1.30	-0.03	1.36	0.48	-0.01	-0.03
Total crop acres	337.42	3.66	1.42	0.67	-0.04	0.51	0.10	-0.02	-0.04

Table 5-5—Change in crop prices

Commodity	Baseline price	AFO 20%	AFO 30%	AFO 40%	AFO 80%	CAFO 20%	CAFO 30%	CAFO 40%	CAFO 80%
	Dollars	*Percent change*							
Corn (Bu)	2.60	-6.03	-2.70	-1.29	0.03	-1.09	-0.21	0.01	0.03
Sorghum (Bu)	2.35	-4.34	-1.61	-0.73	0.01	-0.39	-0.06	0.01	0.01
Barley (Bu)	2.40	-2.22	-0.48	-0.27	0.01	-0.22	-0.08	0.00	0.01
Oats (Bu)	1.45	-13.12	-7.25	-3.34	0.03	-3.34	-0.43	0.02	0.03
Wheat (Bu)	3.70	-1.56	-0.62	-0.30	0.01	-0.13	-0.02	0.01	0.01
Rice (Cwt)	7.71	-1.65	-1.02	-0.32	0.01	-0.34	-0.14	0.01	0.01
Soybeans (Bu)	6.30	-3.54	-1.88	-0.88	0.02	-0.85	-0.14	0.02	0.02
Cotton (Bale)	312.00	-1.58	-0.78	-0.36	0.01	-0.19	-0.05	0.00	0.01
Silage (Ton)	21.73	-1.38	-0.12	-0.03	0.00	0.02	0.02	0.00	0.00
Hay (Ton)	60.66	-4.36	-1.47	-0.71	0.01	-0.67	-0.22	0.00	0.01

duction. However, these results do not account for other costs that would accompany the passage of new CAFO regulations, such as additional storage, handling, and relocation costs. The aggregate effects on net returns of meeting manure nutrient standards vary across agricultural sectors.

The net effect on the livestock and poultry sectors when only CAFOs meet nutrient standards range from a gain of $89 million (0.3 percent) at the lowest nutrient substitution rate to a loss of over $1 billion (3.2 percent) at the highest substitution rate. Under the more stringent AFO scenarios, net returns to the livestock and poultry sector would increase nearly $5 billion (14.4 percent) under the lowest substitution rate, and decrease nearly $2.5 billion (7.3 percent) under the highest substitution rate. The increase in net returns at low substitution rates is due to the expansion effect of prices responding to supply changes. This holds true for both the AFO and CAFO scenarios.

These results might be surprising to some because the cost of nutrient standards would be greatest at lower substitution rates (as shown in the farm-level analysis). However, increases in prices for animal products, due to the exit from the industry of high-cost producers and thus lower supply, are able to compensate for cost increases. As shown in the Market Interaction Primer (Appendix 5-A), net returns can actually increase if prices for livestock and poultry products in both the domestic and export markets are assumed to be very responsive to changes in production. Those producers able to remain in production are the ones that benefit. If prices are less responsive than assumed in the model, net returns in the livestock and poultry sector would decline.

A composite of potential net returns to livestock and poultry sectors and manure production highlights the differences between the AFO and CAFO scenarios and the influence that willingness to substitute manure nutrients has on the economic performance of the U.S. livestock and poultry sectors (fig. 5-2). As the willingness of cropland operators to substitute manure nutrients for commercial fertilizer decreases, manure production decreases and net returns to livestock and poultry producers increase. The reduction in manure reflects a reduction in the number of animals as marginal production costs increase and high-cost producers leave the industry. The impacts to the animal sector are generally smaller when only CAFOs are required to meet a nutrient standard.

The net effect on returns to the U.S. agricultural sector (crops and animals) under the CAFO scenarios is predicted to range from a loss of $201 million (0.3 percent from baseline estimates of net returns) when substitution rates remain at or near current levels to a loss of $644 million at high substitution rates (1.0 percent) (table 5-6). When all AFOs must meet nutrient standards, effects range from a loss of $1.6 billion (2.4 percent loss relative to the baseline) at high substitution rates to a gain of $2.1 billion (3.2 percent) at low manure-fertilizer substitution rates. In this latter case, the percentage increase in prices under the most stringent scenario (AFO20) is greater than the percentage decrease in supply, resulting in greater net producer returns. The reductions in animal numbers reduce the demand for feed, thereby reducing income for crop producers. Generally, when returns to the livestock and poultry sectors increase, returns to crop sectors fall. The aggregate effect on net returns to the entire agricultural sector from imposition of nutrient standards would be negative, except at low manure substitution rates.

At high manure substitution rates, there are few changes in livestock and poultry production and prices, because there is sufficient cropland for spreading manure nutrients at agronomic rates (tables 5-2, 5-3). However, livestock and poultry producers still incur additional costs in transporting manure, developing a nutrient plan, and performing the necessary nutrient tests. Similarly, there are few changes in the production levels and prices for crops at high substitution rates (tables 5-4, 5-5). Returns to cropland operators would increase due to savings from substituting manure nutrients for commercial fertilizer. These savings at high nutrient substitution rates do not fully compensate for the increasing costs to the livestock and poultry sectors, resulting in net losses to the agricultural sector as a whole (table 5-6).

Projected quantity and price changes for crop, livestock, and poultry sectors would be the greatest with

Figure 5-2
National level net returns and manure generation

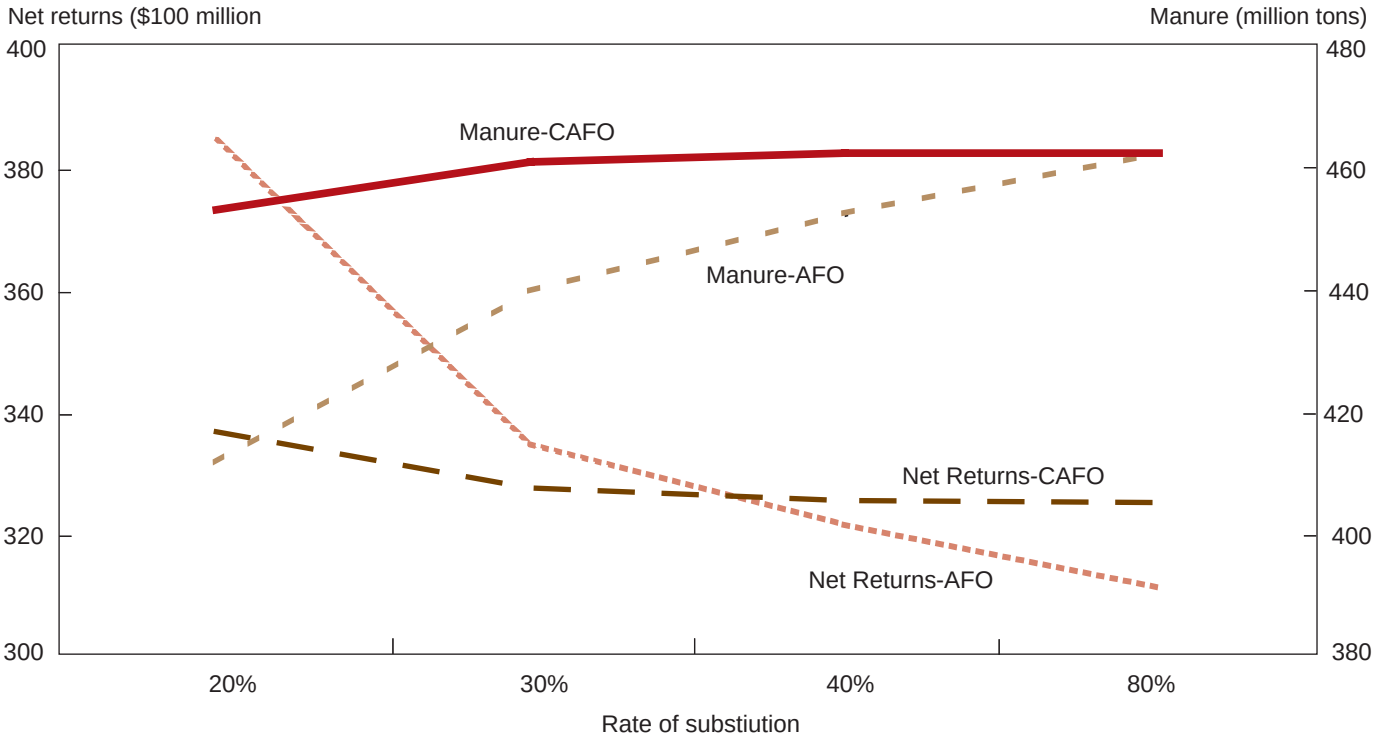


Table 5-6—Change in net returns

Sector	AFO 20%	AFO 30%	AFO 40%	AFO 80%	CAFO 20%	CAFO 30%	CAFO 40%	CAFO 80%
				$ Million				
Corn	-1,702.2	-697.4	-231.2	194.0	-272.1	17.4	86.5	90.3
Soybeans	-2,332.7	-935.0	-206.3	399.7	-350.5	90.9	180.7	184.2
All crops	-2,749.2	-814.7	68.7	901.7	-289.9	262.3	426.8	432.2
Dairy	1,250.7	-172.7	-571.4	-889.7	97.7	-125.3	-216.9	-220.2
Swine	1,385.8	401.6	-9.6	-274.1	290.2	-102.0	-117.7	-132.4
Beef	123.1	-284.8	-603.6	-821.1	-378.6	-486.6	-495.3	-506.4
Poultry	2,118.6	-62.3	-255.5	-491.1	79.5	-127.0	-214.9	-216.7
All animals	4,878.3	-118.2	-1,440.1	-2,476.0	88.9	-841.0	-1,044.7	-1,075.7
Total	2,129.1	-932.9	-1,371.4	-1,574.3	-201.0	-578.8	-617.9	-643.5

manure substitution rates at or near current levels. Livestock and poultry production would decline in general to meet manure nutrient standards, and animal product prices would increase. Incentives would arise for land to come into crop production to meet an increased demand for cropland on which to spread manure. Coupled with decreasing demand for livestock and poultry feed, this effect would result in decreasing prices and increasing quantities for the crop sector. In the most restrictive scenario, where all confined animal operations adopt manure nutrient application standards (AFO scenario) and where relatively few acres are available for manure spreading, the expansion effect in the livestock and poultry sectors would more than offset losses in the cropping sectors, resulting in a net increase in returns to agriculture ($2.1 billion).

While these potential effects of nutrient standards are described in aggregate, individual sectors would experience a range of changes depending on the extent to which livestock and poultry producers adopt nutrient standards and the extent to which cropland operators are willing to substitute manure nutrients. For example, the poultry sector under the most restrictive scenario (AFO20) shows a nearly $2.1 billion increase in net returns. However, at high substitution rates (e.g., 80 percent), the land constraints on manure use would not be binding, even when all AFOs meet the standard. With sufficient land in each region for spreading manure, there would be no decrease in poultry production or increase in prices for poultry products. Consequently, net returns in the poultry sector would fall, due to the higher fixed and variable costs associated with the adoption of nutrient standards.

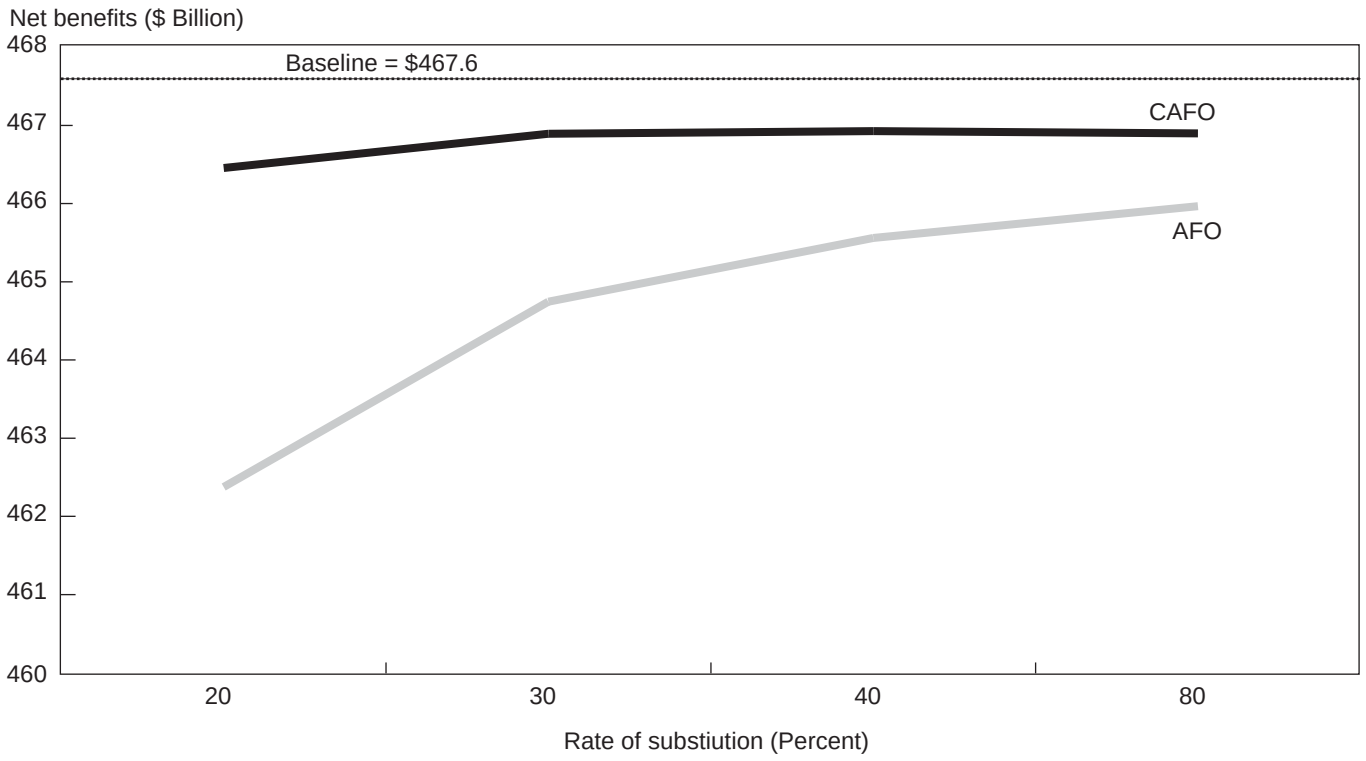
Consider the likely scenario of CAFO20. Net returns increase in the poultry, swine, and dairy sectors, and decrease in the corn, soybean, and beef sectors. The aggregate effect is positive for the livestock and poultry sectors and negative for the crop sector. This illustrates the importance of disentangling aggregate effects to reveal the potential impacts on individual sectors.

National Welfare

Changes in net returns in the agriculture sector (livestock/poultry and crops) are only part of the impacts on the economy. Consumers are affected as prices of commodities change. An aggregate measure of how consumers and producers fare under the alternative policy scenarios expands our analysis even wider (fig. 5-3). As substitution rates decline from 80 percent to 20 percent, manure management costs increase and the net benefits to U.S. agricultural consumers and producers decline (at most, approximately $1.1 billion under CAFO scenarios and $5.2 billion under AFO scenarios). This result suggests that consumers and cropland operators bear the losses when the substitution rate is low, given that the declines in net benefits exceed the increases in net returns to livestock and poultry producers (shown in table 5-6). The opposite can be seen at higher substitution rates. Specifically, under CAFO80, net benefits to U.S. agricultural consumers and producers decline $650 million, yet net returns for cropland operators increase $432 million. Consumers and livestock/poultry producers bear the losses.

These losses could be viewed as the cost for improving U.S. water quality by reducing the amount of manure and redistributing it to regions that can best utilize its potential for crop fertilization. We have not tried to assess the value of environmental benefits from improved water quality, nor have we included

Figure 5-3
Net benefits to consumers and agricultural producers, by substitution rate and CAFO/AFO standard



alternative options for disposing of manure. Industrial technologies may be able to use manure nutrients as inputs in a value-added product. For example, in our most restrictive scenario, the cost of restricting an additional pound of phosphorus from being land applied approaches $30 per pound in the Pacific and Southeast regions, but is less than $5 per pound in the Mountain, Northern Plains, and Corn Belt regions. As such, industrial options that cost less than $30 per pound to reduce phosphorus supply would enhance overall welfare in the Pacific and Southeast regions, but might not be as advantageous in regions with relatively abundant land for manure applications.

Regional View

Because national results may mask regional impacts, we compare performances across the 10 USDA Farm Production Regions. Discerning patterns from these results is sometimes difficult because they are the result of many simultaneous economic forces. It is useful to recall what meeting nutrient standards implies for regional production decisions; i.e., how might a region balance manure nutrient production and agronomic nutrient demands.

Regional Animal Production

The most noticeable changes in animal production levels would occur when substitution rates remain at or near current levels (i.e., when manure nutrients replace only 20 percent of commercial fertilizer). At 20-percent substitution, widespread spatial shifts in production are readily observed. Noticeable changes in the livestock, poultry, and crop sectors are observed at 40 percent. At a substitution rate of 80 percent, only minor changes occur because most areas would have sufficient cropland for spreading manure.

When only CAFOs must meet nutrient standards, changes are generally small (fig. 5-4a). However, animal numbers drop more than 20 percent in the Appalachia, Pacific, and Southeast regions under the CAFO20 scenario. Other regions increase production. Under the AFO scenarios, where all operations adopt nutrient standards, production declines occur in all the regions except for the Corn Belt, Mountain, Lake, and Northern Plains (fig. 5-4b). Reductions are greatest when the substitution of manure for commercial fertilizer is lowest.

Crop Acreage

Overall, crop acreage changes little (0.5 percent or less) when only CAFOs adhere to a nutrient standard (fig. 5-5a). When all AFOs meet a nutrient standard, changes in crop acreage are slightly greater (0 to 3.7 percent) (fig. 5-5b). Acreage increases could occur in those regions where the demand for land to spread manure is high. These increases allow at least some of

Figure 5-4a
Animal production when only CAFOs meet nutrient standards

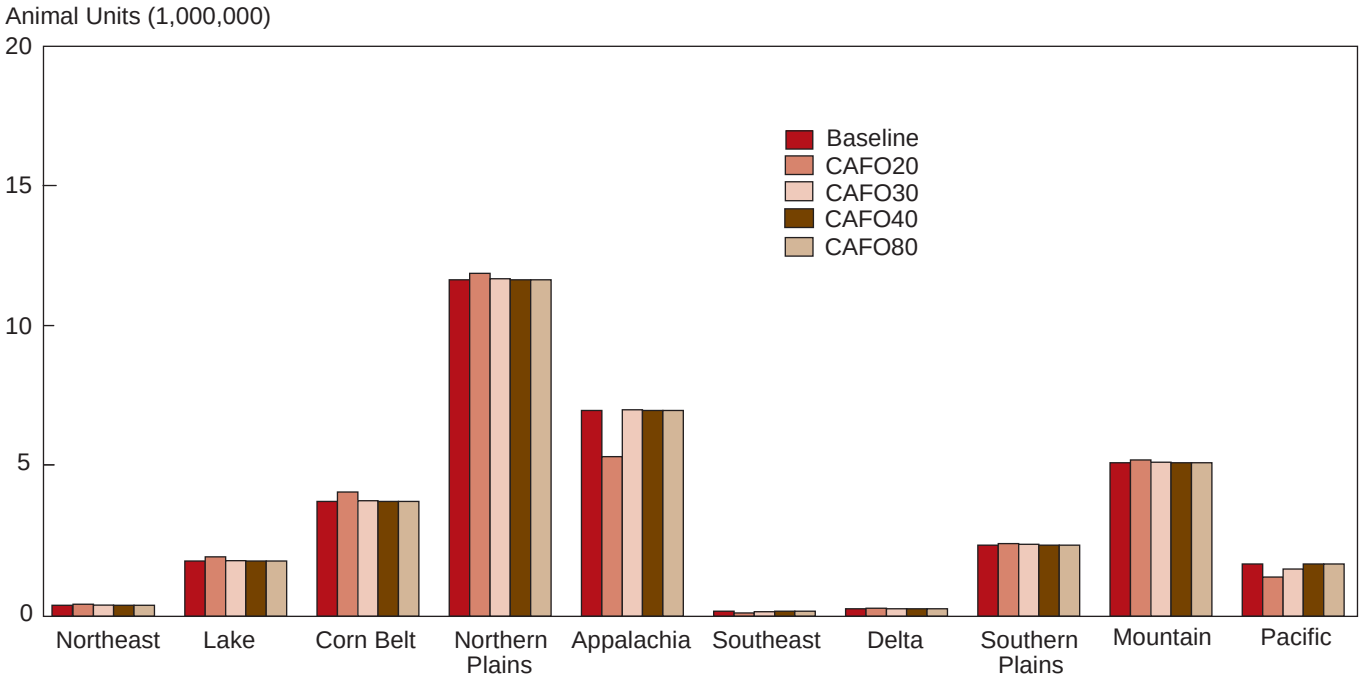
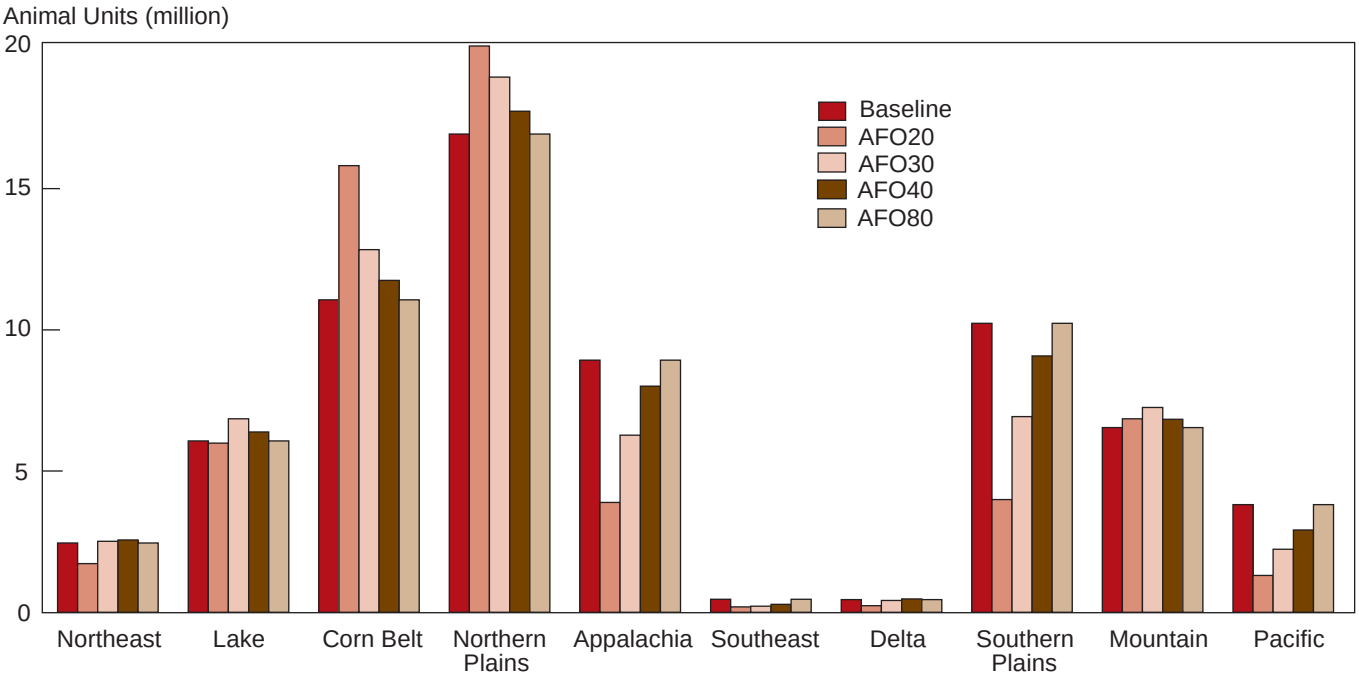


Figure 5-4b
Animal production when all AFOs meet nutrient standards



the livestock and poultry production at the margin to remain viable, particularly in the Appalachia, Southeast, and Pacific regions. The Corn Belt is the only region to show noticeable declines in crop acreage.

Transportation Costs

Transportation costs for hauling manure are a large contributor to the costs of meeting a manure-nutrient application standard. Hauling costs differ between regions because each region has different amounts of land available for spreading manure, different mixes of

Figure 5-5a

Crop acreage when only CAFOs meet nutrient standards

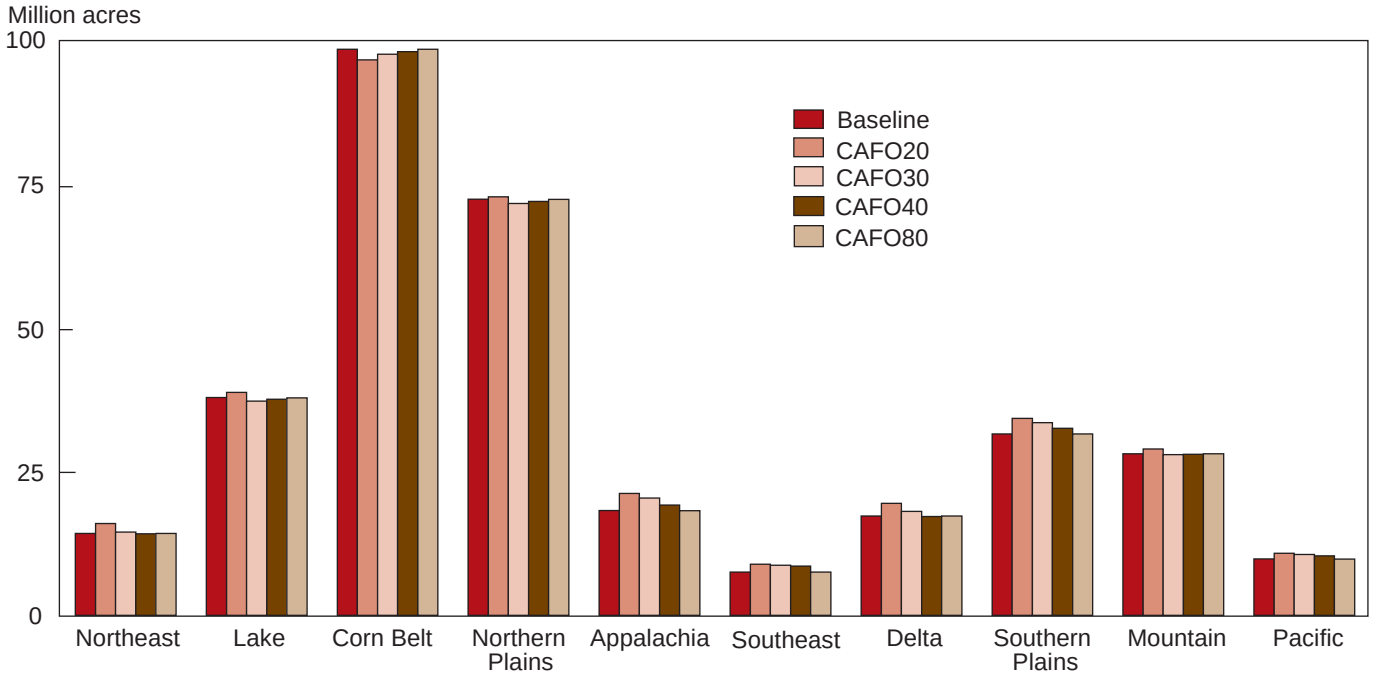
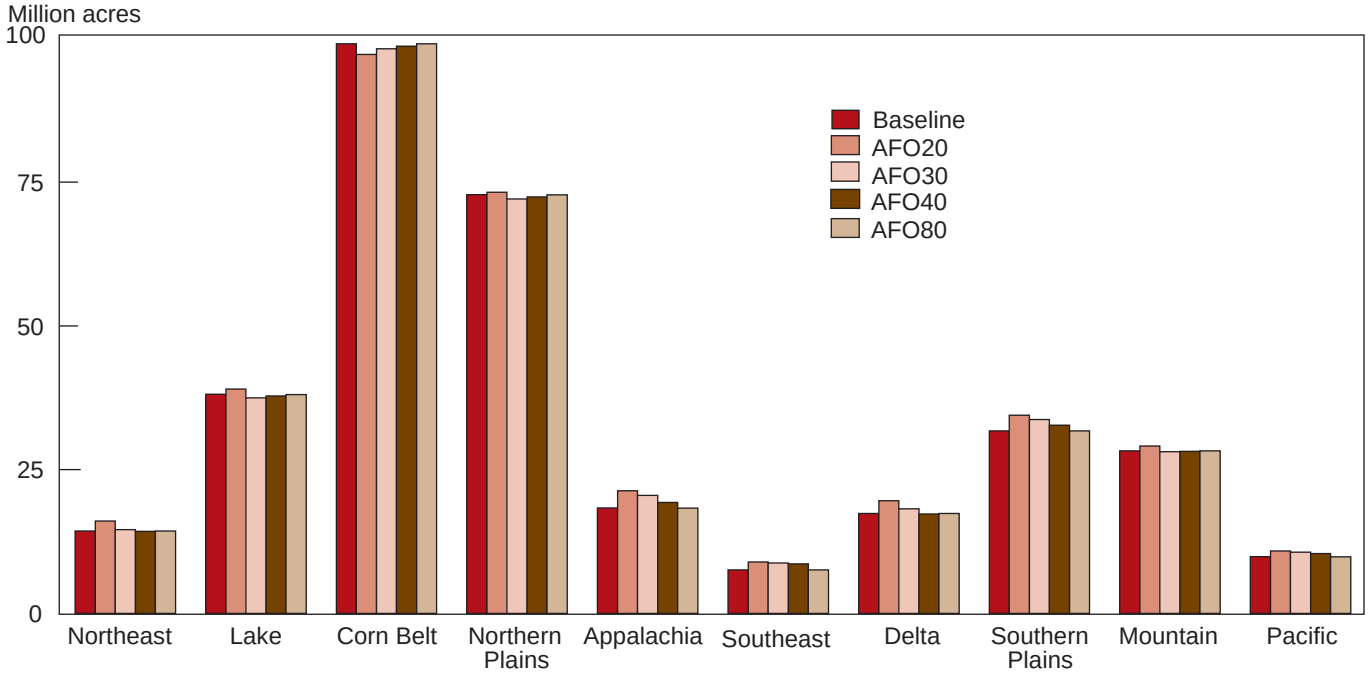


Figure 5-5b

Crop acreage when only AFOs meet nutrient standards



predominant crops, and different quantities of manure that need to be spread. Changes in transportation costs generally move in concert with changes in the number of animals.

Transportation costs remain fairly constant across the CAFO scenarios (fig. 5-6a). Under the CAFO20 scenario, estimated transportation costs range from $33.4 million per year in the Northeast to $237 million in the Northern Plains, where the most animals are produced. Transportation costs can also be viewed in terms of dollars per ton of manure transported. Under the CAFO20 scenario, these costs range from $2.46 per ton in Appalachia to $6.05 in the Pacific region.

Greater changes in transportation costs (relative to the baseline) are seen when all AFOs adhere to the nutrient standard (fig. 5-6b) Transportation costs are high-

Figure 5-6a

Manure transportation costs when only CAFOs meet nutrient standards

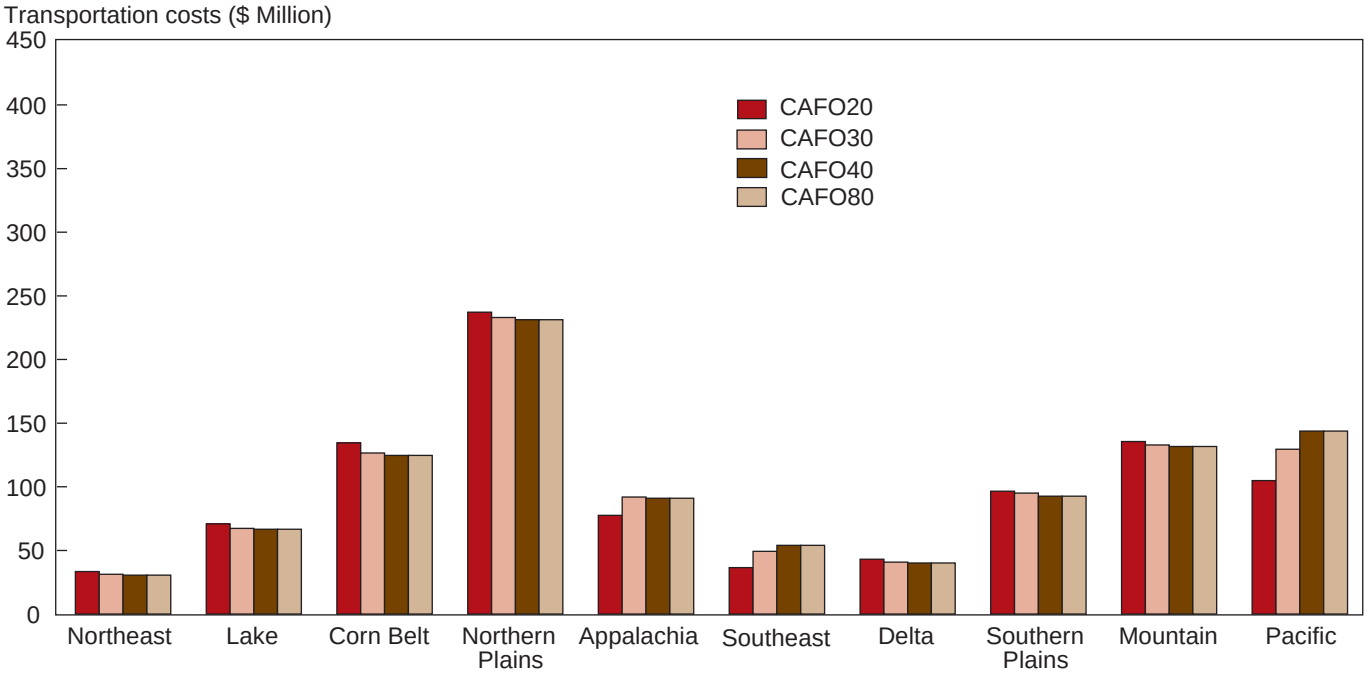
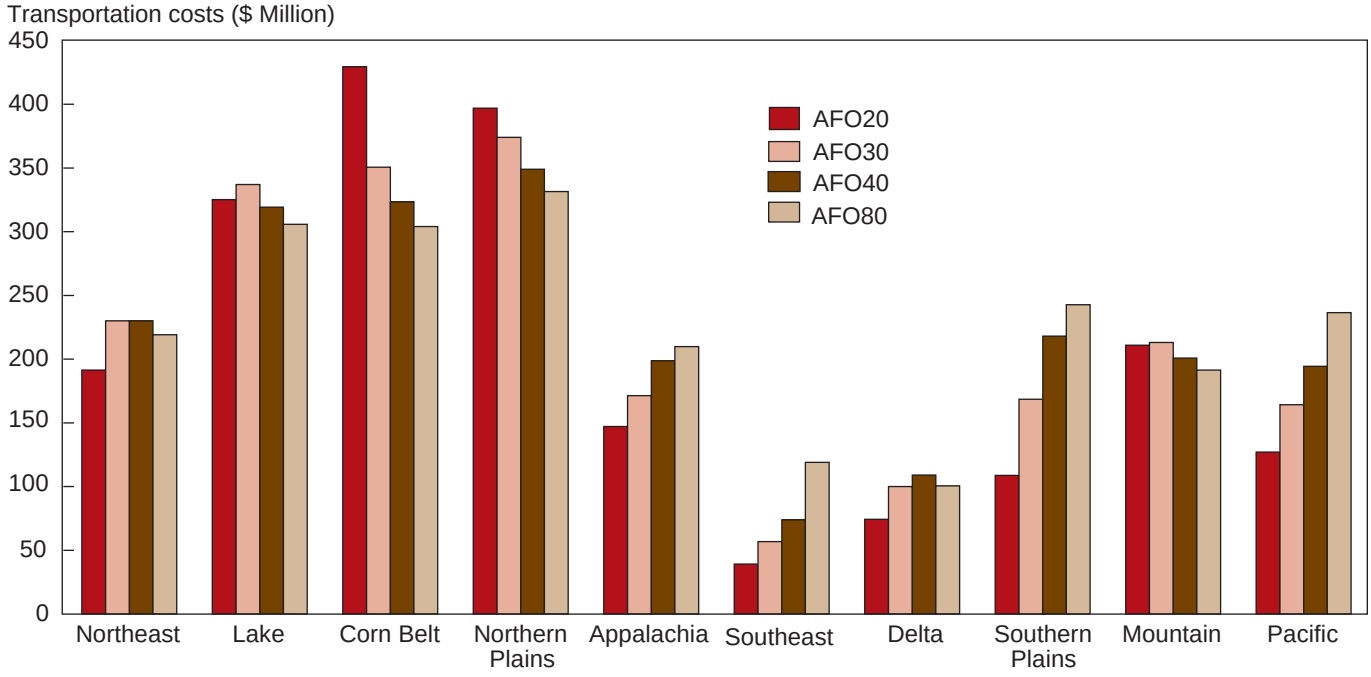


Figure 5-6b

Manure transportation costs when all AFOs meet nutrient standards



est in the Lake, Corn Belt, and Northern Plains regions and typically fall as substitution rates increase. However, in the Southern Plains, Pacific, Appalachia, and Southeast regions, transportation costs are greatest when substitution of manure nutrients is high, and decline noticeably when the willingness of cropland operators to use manure nutrients declines. This result mirrors changes in animal production shown in figure 5-4b.

Fertilizer Savings

Throughout our analysis, we assume that substituting manure nutrients for commercial fertilizer would generate savings for cropland operators (Lazarus and Koehler, 2002). Savings would closely follow the regional quantities of manure generated and the assumed willingness of cropland operators to use manure (table 5-1). Nationally, savings for cropland

operators would increase as more livestock and poultry operations meet standards and as more manure nutrients are substituted by cropland operators. When all AFOs meet standards and 80 percent of cropland operators substitute manure nutrients, savings would total $887 million (assuming no change in the price of commercial fertilizer). When only CAFOs meet standards and only 20 percent of cropland operators substitute manure, nutrient savings would fall to $393 million as animal production decreases in order to balance manure nutrients with available cropland.

Regionally, the story is more complex. When only CAFOs meet standards, the region showing the greatest savings at higher substitution rates (30 percent, 40 percent, and 80 percent) would be Appalachia ($70 million) (fig. 5-7a). Even though CAFOs in Appalachia would not generate as much manure as those in the Northern Plains, the manure content would be more valuable (a higher phosphorus-to-nitrogen ratio), reflecting the larger concentration of poultry producers. However, at low substitution rates (e.g., 20 percent), the nutrient standards would become more binding in Appalachia and animal production would decrease. Consequently, at the 20-percent substitution rate, the potential savings from manure nutrients would be greatest in the Northern Plains ($70 million).

When all AFOs meet standards and the substitution rate is low (e.g., 20 percent), the greatest savings to cropland operators would occur in the Corn Belt, totaling more than $201 million (fig. 5-7b). This region has an abundance of animals and cropland and, as expected, savings would be substantial. However, as substitution rates increase, savings in the Corn Belt would decrease to $133 million. These changes are correlated to the changes in the numbers of animals produced under the different scenarios.

Net Returns

Changes in net returns to livestock and poultry production vary between regions for many reasons, including availability of cropland and mix of animal types. Under both AFO and CAFO scenarios, net returns would increase in most regions under assumed current nutrient substitution rates (about 20 percent). When only CAFOs meet nutrient standards, net returns in the Corn Belt would increase the most ($502 million or 14 percent). Plentiful land for spreading manure keeps the costs of meeting a standard down in this region, so it benefits most from the price increases (for animal products) that occur. Overall production in the livestock and poultry sector also increases. In contrast, net returns would decrease in the Southeast and Pacific regions (about 24-percent reduction in net returns each), where land suitable for spreading manure is relatively scarce (fig. 5-8a). If all AFOs must meet nutrient standards, the impacts on net returns are magnified. Net returns in all but three regions would increase, with the largest again in the Corn Belt ($3.8 billion or 105 percent). Net returns decrease in the Southeast, Southern Plains, and Pacific (fig. 5-8b).

As nutrient substitution rates increase, the expansion effect is reduced so price increases do not compensate as much for higher manure management costs. Net returns decrease in all regions under both AFO and CAFO scenarios when the substitution rate is 80 percent. Percentage reductions are greatest in the Northern Plains in both the CAFO (7.4 percent) and AFO (11 percent) scenarios.

Implications for Individual Sectors

We report results for the three principal livestock sectors (beef, dairy, and swine), the poultry sector, and the corn and soybean sectors. In general, when constraints from nutrient standards are not binding or marginally binding (i.e., greater than an 80-percent substitution rate), there would be small decreases in returns to all the regional livestock and poultry sectors because of the cost of meeting nutrient standards. There would be little to no corresponding price effect because, for the most part, no decreases in production would occur. However, changes in the various agricultural sectors would be larger when nutrient constraints become more binding (more livestock/poultry operations having to meet nutrient standards and fewer cropland operators substituting manure nutrients for commercial fertilizers).

Beef Sector

Changes to net returns in the beef sector vary widely between regions and manure substitution rates (table 5-7). Under the CAFO20 scenario, net returns to the beef sector fall in most regions (-5.1 percent nationally), approaching $290 million (-54.5 percent) in the Pacific region. Increases in net returns occur in the Northeast, Southeast, Southern Plains, and Mountain regions. As manure nutrient substitution increases, losses are reduced in the Pacific, but greatly increase in the Northern Plains to $218 million (-9.5 percent).

The greatest changes in net returns would occur if all AFOs met a nutrient standard and only 20 percent of commercial fertilizer were replaced by manure nutrients. Six regions would suffer declines in net returns, although national returns would increase by $123 million (1.7 percent). Some regions benefit greatly. The

Figure 5-7a

Savings from manure use when only CAFOs meet nutrient standards

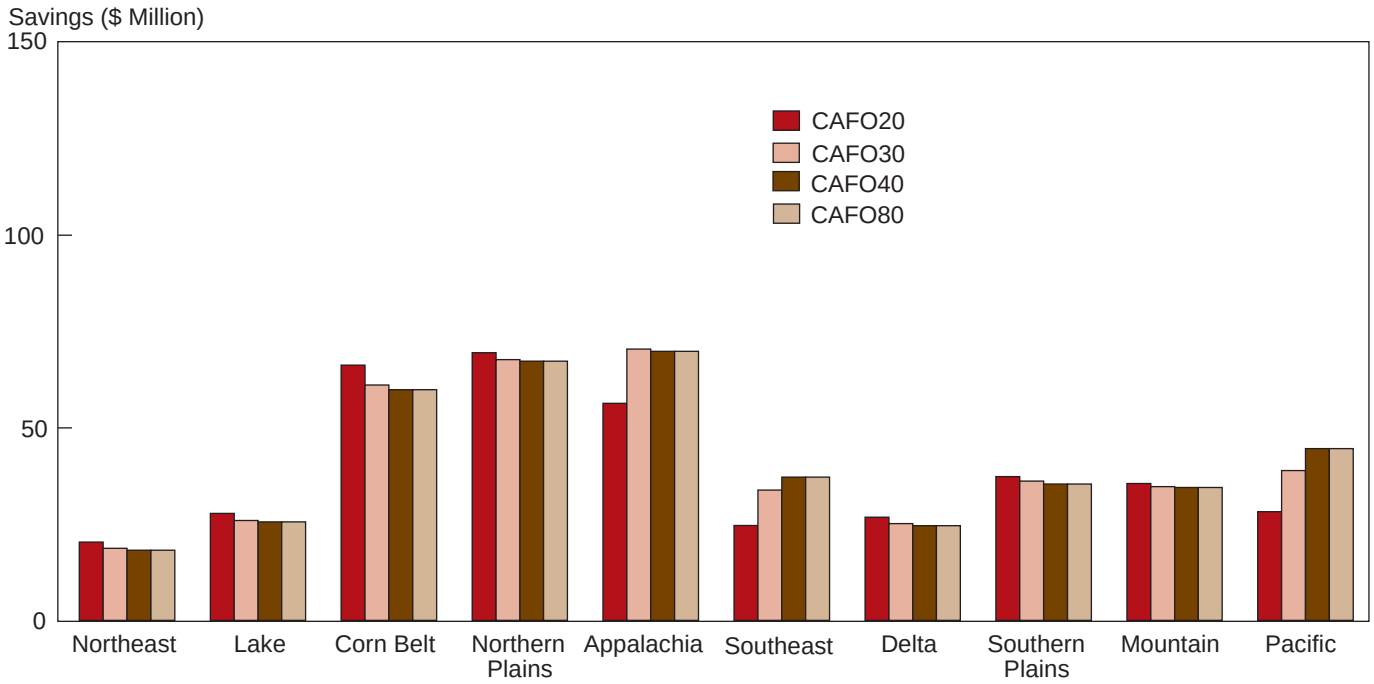
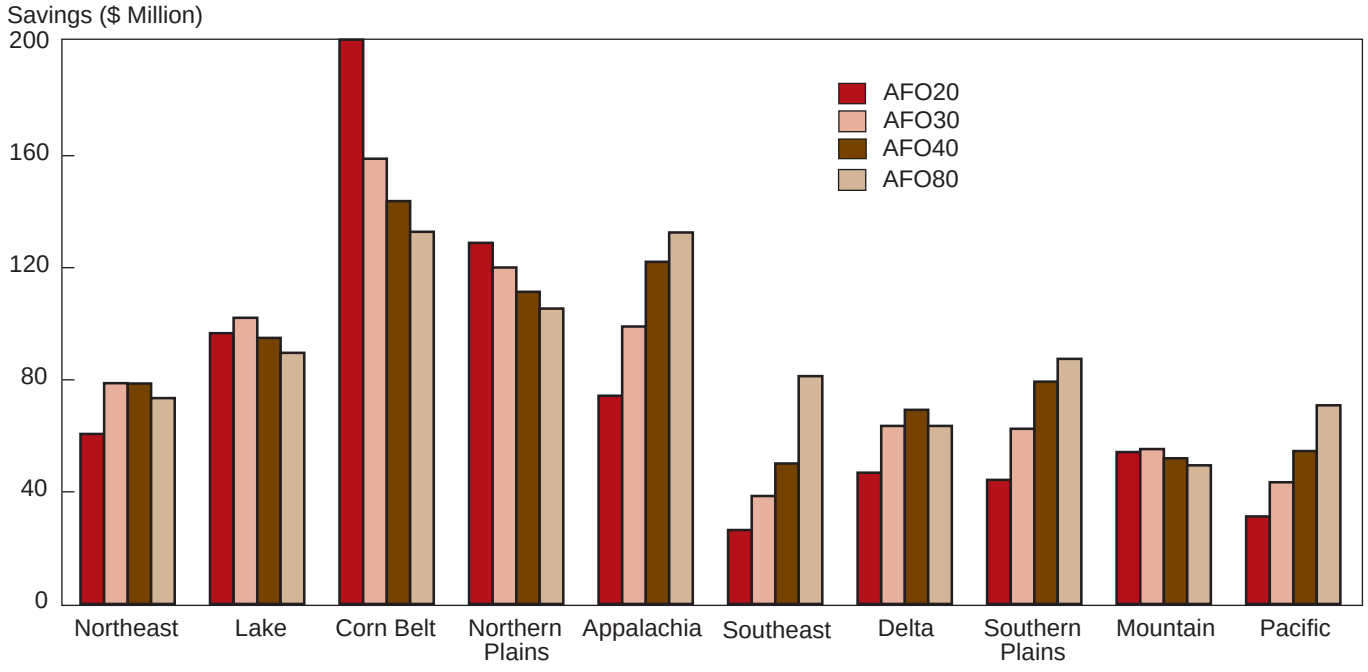


Figure 5-7b

Savings from manure use when all AFOs meet nutrient standards



Northern Plains would enjoy an increase of $986 million (42.8 percent). In contrast, the Southern Plains would suffer a $988 million loss (more than 45.0 percent). As substitution rates increase, the magnitude of the impacts is greatly reduced. When the manure nutrient substitution rate is 80 percent, all but one region suffer losses in net returns, with the greatest loss in the Northern Plains ($291 million).

Dairy Sector

Returns to dairy production would follow a different pattern than seen in the beef sector (table 5-8). When only CAFOs adhere to a nutrient standard, net returns actually increase for most regions (0.7 percent) with substitution near or at current levels. However losses occur in the Southeast and Pacific regions ($3.5 million

Figure 5-8a

Net returns to livestock/poultry production when only CAFOs meet nutrient standards

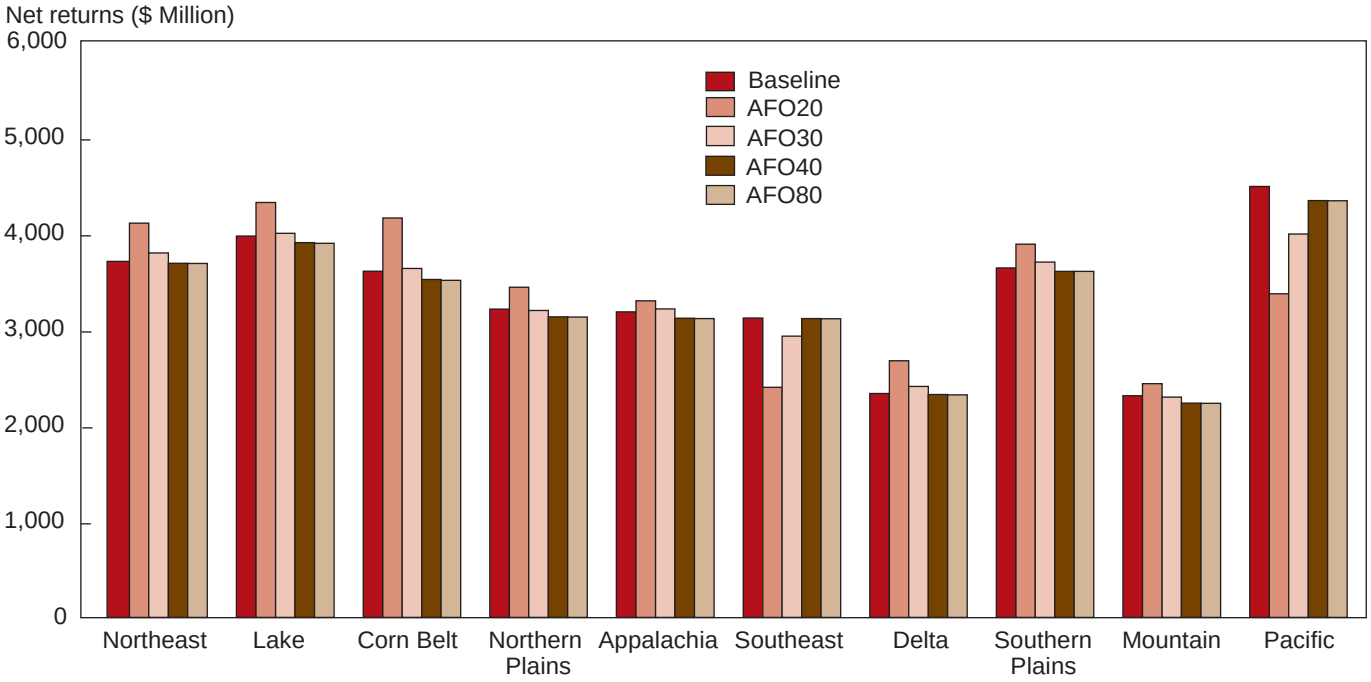
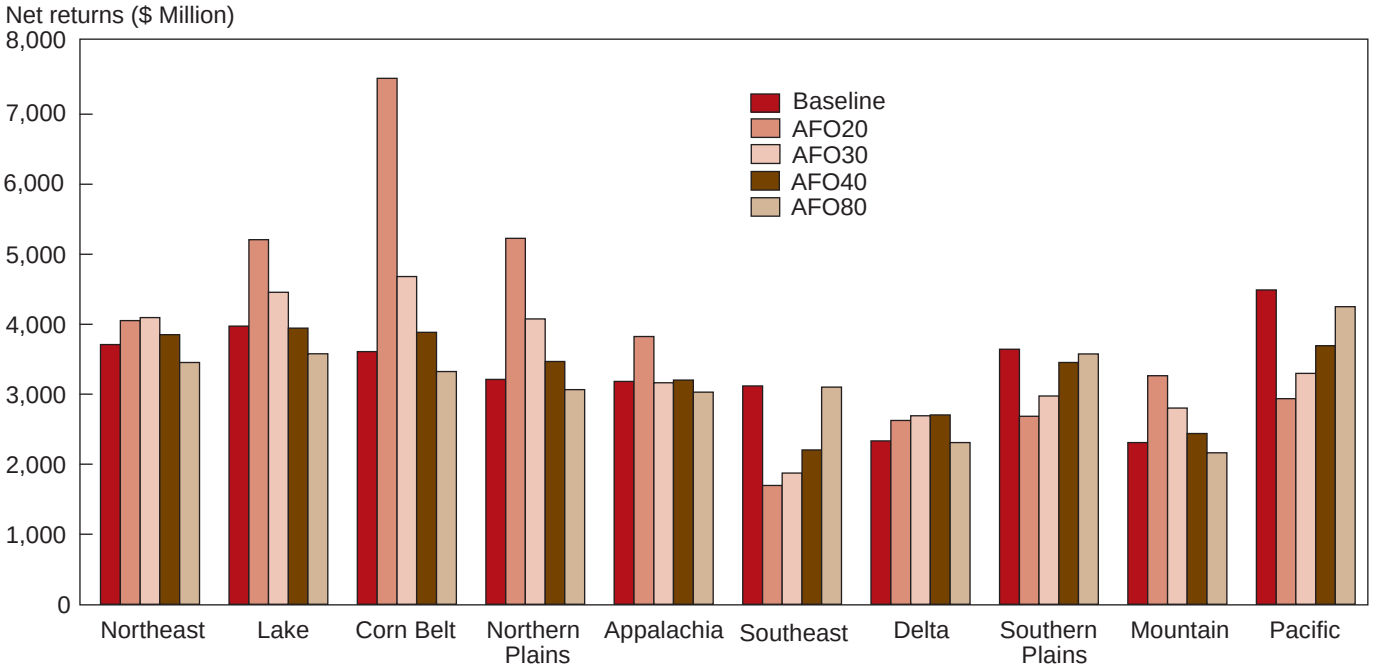


Figure 5-8b

Net returns to livestock/poultry production when all AFOs meet nutrient standards



and $474 million). At higher manure nutrient substitution rates, all regions suffer losses in net returns, with the largest loss in the Pacific ($102 million).

Net returns would increase in most regions if all operations met nutrient standards and substitution rates remain at or near current levels. Net returns for the dairy sector as a whole would increase over $1.2 billion (9.4 percent). The largest increases would occur in the Lake States ($655 million) and Corn Belt ($495 million). The Pacific, however, would see large losses, approaching $625 million (-19.3 percent). As the substitution of manure nutrients for commercial fertilizer increases, the dairy sector as a whole suffers increasingly larger net losses. When manure nutrients substitute for 80 percent of commercial fertilizer, all

Table 5-7—Change in net returns to the beef sector

Region	AFO				CAFO			
	20%	30%	40%	80%	20%	30%	40%	80%
				$ Million				
Northeast	-59.8	-5.0	-0.8	-4.6	1.9	-3.0	-4.5	-4.8
Lake States	-64.3	-8.4	-28.3	-41.2	-3.4	-16.4	-20.3	-22.2
Corn Belt	254.4	11.5	-62.8	-112.0	-22.1	-46.9	-54.8	-57.8
Northern Plains	986.3	361.0	-29.5	-290.6	-82.5	-173.6	-216.3	-218.5
Appalachia	-31.6	-24.0	-17.0	-14.2	-23.8	-12.0	-13.8	-13.9
Southeast	33.5	12.2	5.1	0.0	7.3	1.6	0.0	0.0
Delta States	-43.5	-13.4	-6.4	-10.2	-2.7	-7.2	-8.6	-9.7
Southern Plains	-987.7	-617.5	-312.3	-199.0	24.6	-24.3	-67.9	-68.8
Mountain	526.6	316.8	77.0	-105.2	12.6	-52.0	-89.0	-89.9
Pacific	-490.7	-318.0	-228.8	-43.9	-290.4	-152.9	-20.2	-20.7
U.S.	123.1	-284.8	-603.6	-821.1	-378.6	-486.6	-495.3	-506.4

Table 5-8—Change in net returns to the dairy sector

Region	AFO				CAFO			
	20%	30%	40%	80%	20%	30%	40%	80%
				$ Million				
Northeast	123.1	77.3	-23.6	-181.7	167.4	43.1	-7.9	-8.3
Lake States	654.6	197.2	-53.5	-250.4	188.1	33.8	-29.7	-30.6
Corn Belt	495.5	90.8	-11.0	-90.7	71.5	9.3	-16.2	-16.5
Northern Plains	145.2	31.8	-2.8	-29.8	21.7	0.4	-8.3	-8.3
Appalachia	135.4	-15.5	-31.4	-57.0	44.8	10.0	-6.9	-6.9
Southeast	-12.9	-41.5	-38.4	-9.2	-3.5	-1.6	-2.0	-2.4
Delta States	30.8	12.6	7.3	-5.4	12.5	3.2	-0.5	-0.7
Southern Plains	28.8	-22.7	-7.2	-10.7	37.3	9.3	-2.8	-2.8
Mountain	275.3	64.2	-21.0	-87.2	32.1	-19.9	-41.0	-41.1
Pacific	-625.1	-566.9	-389.8	-167.5	-474.2	-212.9	-101.7	-102.5
U.S.	1,250.7	-172.7	-571.4	-889.7	97.7	-125.3	-216.9	-220.2

regions suffer losses, with the largest in the Lake States ($250 million, or -7.8 percent).

Poultry Sector

The poultry sector in most regions shows increases in net returns (AFO and CAFO) with a 20-percent nutrient substitution assumption (table 5-9). If only CAFOs meet a nutrient standard, net returns for the sector would increase by $79.5 million (0.7 percent) when substitution rates remain at or near current levels, with all but two regions seeing increases. The Southeast would suffer the greatest losses ($749 million or -28.1 percent). As more manure nutrients are substituted for commercial fertilizer, sector losses start to mount, until all regions suffer losses in net returns.

When all AFOs must meet nutrient standards, the poultry sector realizes a large gain in net returns when nutrient substitution is most limited ($2.1 billion or nearly 20 percent). The Corn Belt in particular would benefit, enjoying an increase of $1.9 billion. In contrast, the Southeast would suffer a loss of over $1.4 billion. As the substitution assumption is relaxed, the number of regions with losses increases. When 80 percent of commercial fertilizer is replaced by manure nutrients, net returns decline in all regions, with the largest still occurring in the Southeast ($116 million). Total sector losses reach $491 million (5 percent).

Swine Sector

Net returns to swine production increase relative to the baseline. Under the CAFO20 scenario, most regions benefit (13.5-percent increase nationally), with the largest increase in the Corn Belt ($192 million or 26.6 percent) (table 5-10). As the substitution rate increases to 80 percent, all regions suffer relatively small losses.

Table 5-9—Change in net returns to the poultry sector

Region	AFO				CAFO			
	20%	30%	40%	80%	20%	30%	40%	80%
				$ Million				
Northeast	355.5	318.7	176.7	-44.5	198.4	37.5	-16.9	-17.1
Lake States	574.6	247.2	91.0	-18.2	98.4	17.9	-8.6	-8.7
Corn Belt	1,916.8	592.2	232.6	-51.2	260.7	44.2	-29.9	-30.0
Northern Plains	232.9	86.4	34.1	-6.6	41.9	9.5	-1.7	-1.7
Appalachia	595.0	33.9	39.0	-91.0	133.5	42.9	-27.8	-28.0
Southeast	-1,456.1	-1,245.2	-933.7	-115.7	-749.4	-229.9	-52.9	-53.4
Delta States	255.3	269.5	271.5	-92.0	290.0	46.5	-32.1	-32.7
Southern Plains	-36.8	-125.7	-24.8	-38.2	117.2	17.9	-20.8	-20.9
Mountain	74.5	33.1	14.1	-1.9	17.6	4.4	-0.2	-0.2
Pacific	-393.2	-272.4	-156.0	-31.7	-328.7	-118.0	-23.9	-23.9
U.S.	2,118.6	-62.3	-255.5	-491.1	79.5	-127.0	-214.9	-216.7

Table 5-10—Change in net returns to the swine sector

Region	AFO				CAFO			
	20%	30%	40%	80%	20%	30%	40%	80%
				$ Million				
Northeast	-59.7	5.2	-0.4	-11.8	15.1	-3.3	-4.1	-5.4
Lake States	114.0	89.7	6.2	-40.0	60.6	-12.0	-14.8	-18.0
Corn Belt	1,108.6	280.0	28.3	-109.5	192.3	-26.3	-33.5	-38.2
Northern Plains	400.8	146.7	34.6	-25.5	90.7	-5.7	-8.5	-8.8
Appalachia	-113.3	-76.5	-45.8	-68.1	-69.4	-39.2	-46.9	-50.0
Southeast	-22.3	-22.7	-17.1	-4.6	-10.1	-4.8	-1.4	-1.9
Delta States	-17.7	-0.2	-0.2	-6.1	6.3	-1.8	-2.3	-3.5
Southern Plains	-36.1	-24.4	-9.2	-3.7	6.6	-2.6	-2.9	-3.1
Mountain	23.1	15.7	3.1	-3.7	8.2	-2.6	-2.9	-2.9
Pacific	-11.7	-11.7	-9.2	-1.2	-10.0	-3.9	-0.6	-0.6
U.S.	1,385.8	401.6	-9.6	-274.1	290.2	-102.0	-117.7	-132.4

The largest occurs in the Appalachia region ($50 million, or 7.4 percent).

Under the AFO scenario at the lowest substitution rate, hog returns would decline in 6 of the 10 regions, but national net returns would increase $1.4 billion (more than 64 percent). This is in large part due to the $1.1-billion increase in the Corn Belt. At the highest nutrient substitution rate, net returns decline in all regions, with the largest loss in the Corn Belt ($110 million).

Corn and Soybean Sectors

Balancing manure nutrient production with nutrient uptake in each region can result in shifts in the acreage of various crops and in crop prices (tables 5-11 and 5-12). (We assume that livestock and poultry producers do not pay cropland operators to receive manure.) If CAFOs are the only operations adhering to a nutrient standard, net returns to corn producers decrease in most regions (and -1.7 percent nationally) at 20-percent substitution. Increased willingness to substitute manure nutrients for commercial fertilizer quickly reverses the impacts so that all regions enjoy increases in net returns. If all animal operations met nutrient standards, net returns to corn producers would decline everywhere except in the Pacific region (and -10.6 percent nationally) under low substitution rates. Net returns would decline by over $1 billion (nearly 11 percent) in the Corn Belt, driven by the large volume of corn grown there and the projected declines in crop prices given production increases throughout the United States. At the highest rates of substitution, net returns increase in all regions, with the Corn Belt seeing the largest increase ($60 million or 0.6 percent). Price changes in this scenario are negligible, so the results reflect savings in fertilizer expenditures.

Table 5-11—Change in net returns to the corn sector

Region	AFO				CAFO			
	20%	30%	40%	80%	20%	30%	40%	80%
				$ Million				
Northeast	-29.5	-12.1	1.0	17.4	-9.9	1.4	4.3	4.4
Lake States	-182.3	-74.2	-20.3	30.8	-34.8	0.0	9.0	9.5
Corn Belt	-1,054.4	-453.2	-188.9	59.8	-183.7	-16.1	27.3	29.3
Northern Plains	-306.7	-158.5	-67.0	22.2	-63.0	-2.5	13.9	14.9
Appalachia	-74.3	-11.8	12.6	32.6	1.4	12.9	17.2	17.3
Southeast	-12.2	12.2	22.7	21.8	15.6	13.4	10.0	10.1
Delta States	-12.6	-2.1	-0.8	2.3	-1.8	0.4	0.9	0.9
Southern Plains	-11.4	2.3	3.0	2.9	-4.2	-0.1	1.2	1.3
Mountain	-26.5	-12.6	-5.2	1.8	-4.7	0.0	1.2	1.3
Pacific	7.7	12.7	11.6	2.3	13.1	8.0	1.4	1.5
U.S.	-1,702.2	-697.4	-231.2	194.0	-272.1	17.4	86.5	90.3

Table 5-12—Change in net returns to the soybean sector

Region	AFO				CAFO			
	20%	30%	40%	80%	20%	30%	40%	80%
				$ Million				
Northeast	-1.4	1.4	3.5	5.7	-0.9	1.0	1.5	1.4
Lake States	-58.9	-18.1	2.3	21.0	-12.3	2.9	6.3	6.4
Corn Belt	-403.1	-196.4	-65.9	52.6	-90.4	3.7	25.0	24.7
Northern Plains	-59.6	-31.6	-8.0	12.8	-12.2	4.5	8.3	8.3
Appalachia	-43.1	-3.9	24.0	39.8	2.5	19.2	21.1	21.1
Southeast	5.6	20.9	31.5	35.7	19.1	20.6	16.4	16.4
Delta States	-75.8	-22.2	25.5	34.8	3.0	13.2	13.7	13.8
Southern Plains	-1.8	-0.5	0.4	1.0	-0.2	0.3	0.4	0.4
Mountain	na	na	na	na	na	na	na	na
Pacific	na	na	na	na	na	na	na	na
U.S.	-2,332.7	-935.0	-206.3	399.7	-350.5	90.9	180.7	184.2

na = Not applicable (crop not grown).

A similar story emerges for soybeans. When only CAFOs meet nutrient standards, most regions would see reduction in net returns (-4.5 percent relative to the baseline) at 20-percent substitution. When 30 percent and more of commercial fertilizer is replaced by manure nutrients, net returns increase in all regions (2.4 percent for the sector with 80-percent substitution). The greatest losses (nearly 30 percent nationally) would occur if all operations met nutrient standards and if manure nutrients replaced only 20 percent of commercial fertilizer. Net returns would decrease in almost all regions, with the largest loss occurring in the Corn Belt ($403 million). In contrast, net returns to soybeans would increase in all regions (5.2 percent nationally) if 80 percent of commercial fertilizer were replaced with manure.

Summary

The new CAFO regulations could have many possible outcomes. As in the previous two chapters, we have focused on only one aspect of this proposed rule: the adoption of nutrient standards by confined animal feeding operations. However, while chapter 3 focused on farm-level implications and chapter 4 considered regional costs for the Chesapeake Bay watershed, this analysis considers the U.S. agriculture sector holistically. To do this, we model eight possible scenarios based on adoption and substitution rates for implementing nutrient standards for various sectors of U.S. agriculture, with the most likely scenarios being substitution rates of 20 percent (CAFO20) and 30 percent (CAFO30). The eight scenarios also vary in scope. Four scenarios consider implications of CAFO-only requirements, while the other four are more extreme,

requiring all AFOs to meet nutrient application standards. The results from these scenarios are compared with the USDA 2010 baseline, a year when it is assumed that the agricultural sector will have adjusted to the adoption of nutrient standards.

The imposition of nutrient standards on animal feeding operations is estimated to result in net economic gains of $89 million (or a 0.3-percent increase in net returns) for the livestock and poultry sectors under CAFO20, though individual producers may gain or lose. The price increases that result in an overall increase in net returns are the result of a reduction in the number of animals being produced. Benefits are realized only by those operations that remain in production. However, the livestock and poultry sector suffers economic losses of $841 million (2.5-percent decrease) under CAFO30. This swing is attributed to the livestock supply-dampening and price-enhancing effects observed in the CAFO20 scenario. Economic losses to consumers (higher prices) plus producers are $1.1 billion (-0.23 percent) and $0.66 billion (-0.14 percent decrease) under the CAFO20 and CAFO30 scenarios.

This analysis also showed that requiring all AFOs to meet a nutrient standard would greatly increase the magnitude of national impacts. As of now, only CAFOs are required to meet a nutrient standard. If there is a cost to operations other than CAFOs for meeting a nutrient standard, then they would not voluntarily alter their manure management practices and the estimated price changes would not occur.

There are significant variations in economic impacts between animal types and regions that are hidden by national aggregate results. Within a single scenario, some regions and sectors gain while others lose. For example, while animal feeding operations in aggregate would realize a net gain of $89 million under the CAFO20 scenario, the beef sector would suffer a net loss of $379 million. Furthermore, within the beef sector, the Southern Plains would realize a net gain of $25 million while the Pacific would see a net loss of $290 million. The wide range of results makes it exceedingly difficult to generalize the impacts of the nutrient application restrictions.

This analysis cannot reveal how individual operations would be affected by the standards. What can be said is that the livestock, poultry, and cropping sectors would undergo changes under all scenarios considered. The livestock and poultry sectors would benefit in some cases, possibly at the sacrifice of some individual operations, but net returns to the U.S. agriculture sector, including impacts on the cropping sectors, generally fall. However, these losses must be weighed against improved surface and ground water (from reduced nutrient loadings), the benefits of which are not estimated in this analysis.

Changes to agricultural sectors in response to manure nutrient application standards will not occur in a vacuum. Other technologies for treating manure nutrients might develop over time. In regions where cropland for spreading manure nutrients is scarce, it is likely that other nonagricultural lands (such as on timber plantations) would be used for assimilating manure nutrients. Similarly, other agri-environmental policies may bear on these issues. For example, the 2002 Farm Act provides a large increase in funds intended to help livestock and poultry producers to comply with Federal and State water quality regulations and to encourage the adoption of practices such as nutrient management. These policies could alter the changes in production arising from the adoption of nutrient standards. Specifically, the Environmental Quality Incentives Program (EQIP) is authorized to fund $9 billion of manure management and conservation efforts by crop, livestock, and poultry producers over the next 10 years (USDA, NRCS, 2002). This amount exceeds total agricultural losses under five of the eight scenarios we analyzed. While implementation of EQIP will reduce farmer costs of responding to CAFO regulations—indeed it is designed to do so—we did not explicitly analyze this option. Instead, we raise this as a topic to be addressed in future research.

Appendix 5-A

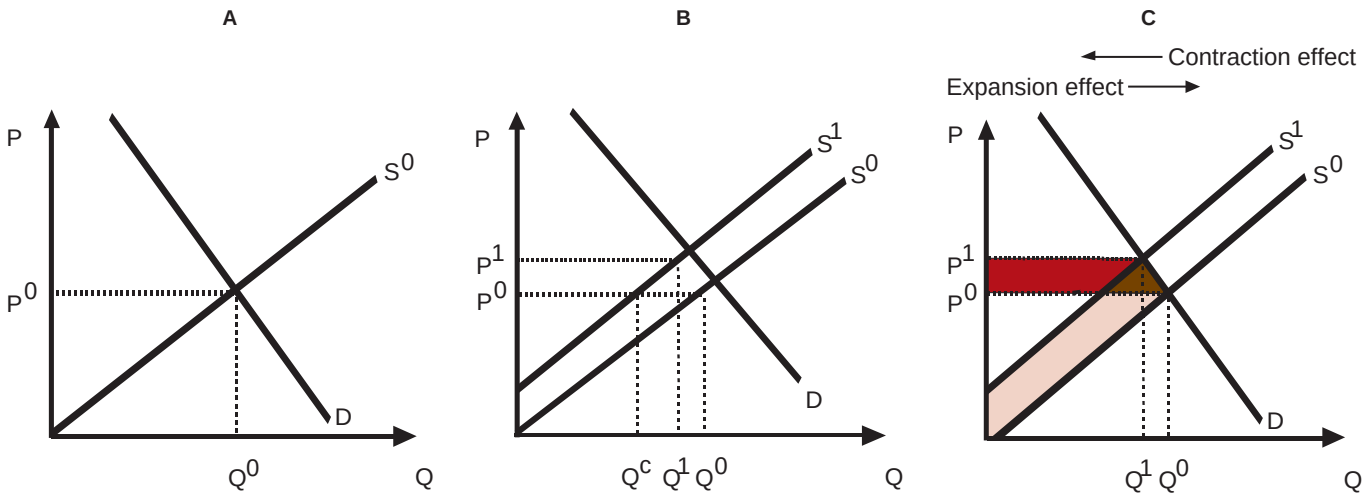
Market Interaction Primer

If animal feeding operations (AFO) adopt land application restrictions for manure nutrients, the marketplace could react in several ways (fig. 5-A-1). In figure 5-A-1-A, the intersection of initial supply (S^0) and demand (D) for livestock and poultry products establishes the market clearing quantity and price for exchange (Q^0, P^0). If AFOs adopt nutrient standards, production would decline as a result of increased costs of production. Decreased production would result in a shift in the supply of livestock and poultry products (a movement from S^0 to S^1 and a corresponding change in quantity supplied to Q^c, as shown in figure 5-A-1-B). A new market-clearing quantity would then be established at a higher price, re-equilibrating supply and demand (i.e., at Q^1, P^1). Note that the slope of the demand curve will determine the extent to which prices increase. For instance, if the demand curve were horizontal (an extreme assumption), the effect would be contraction but not price changes.

Two inferences can be gleaned from this example. First, assuming downward sloping demand curves, consumers would purchase fewer livestock and poultry products at the higher price. Second, producers would reduce the supply of livestock and poultry products but would receive a higher price for their products. Clearly, consumers would be worse off. The potential loss to consumers is shown by the dark red and brown shaded areas in figure 5-A-1-C. The situation for the industry is less certain and would ultimately depend on the interaction between production changes, price changes, and increased production costs. These interactions would, in turn, depend on the responsiveness of prices for livestock and poultry products in both the domestic and export markets following changes in the cost of production. If the increased returns to producers depicted by the dark red shaded area exceeds the lost returns (the tan shaded area) then the industry, as a whole, would benefit even though individual producers with relatively higher costs may exit the industry.

We would expect the responses of AFOs to the standards to vary regionally. As noted, increased costs would initially result in reduced livestock and poultry production. However, under nutrient standards, some regions would face greater increases in the cost of production than others, due to such factors as available land for manure spreading. This was clearly shown in the farm level analysis in chapter 3. Figure 5-A-2 use hypothetical supply and demand curves to depict two heterogeneous regions. The contraction in supply due to nutrient standards is shown for the two regions by a movement from s^0 to s^1. A corresponding expansion effect, or positive supply response due to increased livestock and poultry prices, accompanies this contraction (Silberberg, 1990). The national market-clearing price would increase from P^0 to P^1. We assume that regional markets are price takers and thus the demand curve is depicted by the horizontal line equivalent to the prevailing price. In Region A, where the supply shift would be relatively small, production increases overall due to the supply response to the new higher price.

Figure 5-A-1
U.S. supply and demand for livestock and poultry products



Region A experiences increased net returns arising from the implementation of nutrient standards throughout the United States. This region's operators would produce more and receive a higher price for their products even though they face greater costs of production. In Region B, the supply shift is relatively large and the price response does not compensate for the increased production costs. Consequently, production falls in Region B due to the increased cost of production brought about by the change in production practices.

Figure 5-A-2

Heterogeneous production shifts resulting from nutrient standards