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USDA'S ASSESSMENT OF THE COSTS OF MANAGING MANURE NUTRIENTS
WITH LAND APPLICATION

Noel R. Gollehon
Agricultural Economist, Economic Research Service
U.S. Department of Agriculture

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 overapplied to land and enter water resources through runoff or leaching. The nutrients of greatest water quality concern are nitrogen and phosphorus. Animal waste is a source of both.

The past several decades have seen a shift in the livestock and poultry industry toward fewer, larger operations with a reduced amount of available cropland per animal on livestock and poultry farms (Gollehon et al., 2001). Concerns have consequently arisen that crops and other vegetation are not fully assimilating nutrients in manure, and that excess nutrients are increasingly likely to degrade nearby water resources. The land application rate—the quantity of manure spread on an acre of land—is believed to be the single most important manure management decision affecting the potential for contamination of water resources by manure nutrients (Mulla et al., 1999).

Public concerns over the use and disposal of animal manure has risen. In response, State and Federal environmental protection authorities now require that manure be handled and applied to land so as to minimize runoff and leaching, often with impacts on livestock and poultry production costs. The Unified Strategy for Animal Feeding Operations, jointly developed by the U.S. Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) in 1999, states: “Land application is the most common, and usually most desirable method of utilizing manure because of the value of the nutrients and organic matter. Land application should be planned to ensure that the proper amounts of all nutrients are applied in a way that does not cause harm to the environment or to public health. Land application in accordance with a comprehensive nutrient management plan (CNMP) should minimize water quality and public health risk” (USDA-EPA, 1999, pp. 8-9). A goal of the Unified Strategy is that all animal feeding operations—regardless of size—voluntarily adopt CNMPs for managing their nutrient resources, including both commercial fertilizer and animal manure.

More recently, rules promulgated in 2003 by EPA are designed to change the way the largest animal operations are handled under the Clean Water Act. Under the new regulations, “concentrated animal feeding operations” (CAFOs) will be **required** to meet nutrient application standards as defined in a nutrient management plan. The plan will become a part of the National Pollutant Discharge Elimination System (NPDES) permits that required of all CAFOs. Violations of the permit are subject to fines and/or facility closure.

Implementation of nutrient standards for manure application will raise manure management costs for many farms. In many cases, restrictions on manure applied per acre will require operators to find additional land on which to spread manure, increasing the cost of transporting and applying animal manure to the land. If additional land off the farm is required, animal operations may incur rental payments or disposal fees, although the animal operation typically covers only the cost of hauling and applying manure.

In some areas of the country, large concentrations of confined animals would likely strain the ability of an individual CAFO to secure adequate land locally for spreading manure. The competition for land would likely elevate waste-handling costs since some operators would be forced to transport manure over longer distances for disposal. The willingness of crop producers to accept animal manure from livestock and poultry operations will also determine the availability of land for manure application and hauling distance. High transportation costs regionally could encourage the development and expansion of alternative uses of manure, such as for commercial fertilizer or energy production. Over the longer term, high manure management costs may prompt structural adjustments in the animal industry, inducing operations to spread out geographically, to relocate to areas with more abundant land, or to reduce herd size.

Implementation of new requirements on animal waste management could affect not only producers, but consumers as well. A substantial spike in waste management costs could result in regional shifts in animal production and adjusted prices for animal products and certain feedgrains and other crops.

The ERS Analysis

As with all research, the strengths and limitations of this analysis are framed by the study objectives and reflected in the study's scope, methodology, and analytic assumptions. While motivated by Federal policy provisions first proposed in 1999, this study is not intended as a direct examination of either EPA's new CAFO regulations or USDA's nutrient management policies. Rather, the study provides an independent analysis of a key provision of these and other Federal and State animal waste initiatives—the land application of manure at agronomic rates. The study examines the costs and feasibility of reliance on land application for manure disposal and the effect of key factors (including policy provisions) on these costs.

The ERS analysis examines the effect of key variables on land application feasibility, costs and the resulting impacts on the market system. The Natural Resources Conservation Service (NRCS) analysis in the following paper assesses the costs of CNMP development and implementation under existing conditions and management approaches. To ensure consistency between the ERS and NRCS reports, both agencies used common data sets and similar algorithms for estimating onfarm manure hauling distances and manure nutrient production. Each report received extensive peer review and were published in 2003 (see Ribaud et al., and USDA, NRCS).

The ERS study includes three analytic components—farm-level, regional, and national analysis—to address a range of issues pertinent to the land application question. Each of these analyses focuses on issues best evaluated at its respective scale. The farm-level analysis examines on-farm technical choice and costs at the producer level for hauling manure to the minimum amount of land needed to assimilate manure nutrients when applied at agronomic rates. The regional analysis focuses on off-farm competition for land to spread surplus manure, using the Chesapeake Bay region as a case study. The national, sector-wide analysis addresses potential long-term structural adjustments at the national level and ultimate costs to consumers and producers.

While there are many differences in the scale, scope of analysis, economic variables, and assumptions regarding facets of the animal industry, there are several unifying elements. Crop producer willingness to accept manure and its influence on producer costs is a critical factor across analyses. Finally, the cost coefficients used to characterize the nutrient management policies, as well as the physical coefficients used to convert animal numbers to manure nutrients, are consistent among the three ERS analyses.

This paper provides an indication of the type of analysis conducted, highlighting a few of the major findings. Much more detail on the methods, analysis, findings and conclusions is available in Ribaud et al., *Manure Management for Water Quality: Costs to Animal Feeding Operations of Applying Manure Nutrients to Land*, Agricultural Economics Report 824, June 2003, available online at <http://www.ers.usda.gov/publications/AER824/>.

Farm-Level Analysis

We used data from the 1998 hog Agricultural Resource Management Survey (ARMS) and the 2000 dairy ARMS (USDA, ERS, 2002) to demonstrate how the nutrient management goals of EPA and USDA might affect a particular livestock sector. For each sector, we examine the consistency of current land application decisions (referred to as the baseline) against nutrient standards that are based on agronomic needs. We then use a land application cost model to estimate the cost of spreading manure according to a nutrient standard while considering the availability of cropland and the willingness of non-livestock producers to accept manure as a source of nutrients.

We consider both nitrogen-based and phosphorus-based standards, as either might be required or recommended at any given location based on the phosphorus content of the soil. For both the nitrogen- and phosphorus-based standards, we assume a strict interpretation where the standard must be met every year on every acre receiving manure.

Results indicate that implementing a nutrient management plan for meeting a standard (plan development and testing) and hauling/ applying manure to fields both add to the cost of producing animals. These costs will vary by species, by the size of the operation, and by region. The average costs of meeting a standard (per animal unit) across farm sizes and regions range from -\$4/AU to \$27.3/AU for hogs, and \$0.2/AU to \$88.3/AU for dairy (Figure 1).

Large farms, those typically designated as CAFOs by EPA, would generally see greater percentage increases in production costs from meeting nutrient standards than would smaller farms. At low levels of willingness-to-accept-manure (WTAM) (10 percent), production costs can increase more than 5 percent for large hog producers in some regions if a P-standard is enforced (costs ranging from \$1.60/AU to \$27.30/AU). Costs are lower in the Corn Belt regions where land to receive manure is more readily available both on and off the farm. Similar results are seen for large dairies—costs range across regions from \$74.10/AU (North) to \$88.20/AU (South) with a WTAM of 10 percent. For small operations, production costs generally increase less than 1 percent at any level of WTAM.

Willingness of cropland operators to accept manure greatly influences the net costs to livestock and poultry producers of meeting a nutrient standard. For example, the average cost of meeting an N-standard for large hog farms in the South would drop from \$13.80 per AU to \$1.60 per AU (88-percent decrease) if WTAM were to increase from 10 percent to 80 percent (Figure 2). Manure transportation costs would decline if crop producers were more accepting of manure. Research on their acceptance of manure as a nutrient source would identify constraints that might be overcome through technical assistance, financial assistance, and education.

Our results do not reflect changes in management other than spreading manure on additional acres. Incorporating other management changes would likely lead to a different set of results. For example, farmers might grow crops that take up more nutrients, change manure handling systems, and reduce herd size. These changes would occur over time, and at some expense. The results reported here can be

viewed as an initial adjustment that might foster further adaptation, as farmers evaluate the net costs of manure spreading and consider alternative or additional changes.

Regional Analysis

The costs associated with meeting USDA goals and EPA regulations for improved manure management depend not only on individual farm conditions, but also on the *interaction* among animal operations, within the broader context of off-farm resource conditions. The regional analysis examines the effect of competition for land to spread manure in areas with high animal concentrations.

The regional analysis focuses on the challenges that all animal feeding operations (AFOs) may face in finding suitable land for manure application when there are many producers in the same region needing to apply manure off the farm. Studies by Kellogg et al. (2000) and Gollehon et al. (2001) identified areas where confined animals produce more manure nutrients than can be assimilated on cropland and pastureland in the county of production, when applied at agronomic rates. Notable among these areas were several county clusters within the Chesapeake Bay watershed, which served as the area of study.

In areas of the Chesapeake Bay watershed (CBW) where confined animal production is concentrated, implementation of EPA and USDA manure policies poses tremendous challenges. If the manure produced exceeds potential local assimilative capacity, producers may choose to: (1) transport the manure ever-greater distances until enough land can be found for application, (2) alter feed management to reduce nutrient output, or (3) apply technologies that transform the manure to a value-added product that is more readily transportable and usable. Beyond this, the only recourse would be to reduce the number of animals in the watershed.

The regional analysis relies on a regional manure management optimization model to minimize the cost of manure land application in the region as a whole, while accounting for the competition for land on which to apply manure among animal producers in the CBW. We assume that all AFOs are trying to meet the nutrient management goals laid out in the USDA-EPA Unified Strategy. The model and its results reflect a regional planning perspective emphasizing the feasibility and cost determinants of alternative strategies at the watershed scale.

Results indicate that the willingness of crop producers to accept manure on eligible acres is an important—perhaps the most important—consideration in determining whether land application is a viable stand-alone strategy in the CBW. We find that, at willingness-to-accept-manure (WTAM) levels of 60 percent or lower, there is an insufficient land base to apply all the manure produced under a P-standard, given the modeled transportation radius and no change in land use, crop mix, or animal location. Similarly, all manure cannot be land applied under an N-standard at WTAM levels of 20 percent or lower (Figure 3). Current national data suggest that between 10 and 20 percent of cropland receives manure.

Holding animal production constant, the estimated gross cost for land application of manure ranged from \$123 million to \$155 million per year over the set of solutions in which all manure may be land applied. This is a high proportion of annual total net returns to animal production in the CBW (\$313 million) (Figure 4). Over 60 percent of manure disposition costs were for transport, and less than 30 percent for application/incorporation. Onfarm hauling and distribution of manure accounted for up to 75 percent of the total costs, but the costs tended to be constant in dollar amount over the range of WTAM levels where all manure could be land applied. Most of the cost increases from reduced WTAM levels were associated with off-farm movement of manure. Out-of-county transportation, application, and

incorporation costs were estimated to range between \$9 million and \$55 million, depending on which nutrient standard was in effect and the willingness of crop producers to accept manure.

The net costs of manure management in the CBW depend not only on the total land application cost but also on the potential savings in commercial fertilizer by more efficiently using manure nutrients, as well as on the costs of addressing the manure that could not be land applied due to model transport limits. The potential savings in commercial fertilizer purchases and application costs were estimated at \$60-\$68 million, which offset 40-55 percent of the total costs of applying manure to land. The extent to which the potential nutrient savings are translated into farm returns will influence not only the net manure disposal costs but also a producer's willingness to accept manure. Moreover, some portion of those savings will be felt as reduced revenues to fertilizer suppliers.

Finally, significant quantities of manure under the P-standard could not be land applied in our modeling framework under many WTAM levels. The disposition of this manure remains a challenge, perhaps an expensive challenge, for manure management in the CBW. The need to transport manure over longer distances has structural implications for the agricultural sector. Moving manure to a location that is miles away from the manure source presumes that a marketing structure is in place and that a consistent, standardized product is shipped to the destination. It is likely that new marketing arrangements will develop over time to satisfy this need, spurred on by the new policy.

National Agricultural Sector Analysis

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.

In this modeling framework, 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.

This analysis cannot reveal how individual operations would be affected by nutrient 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 expense 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 ultimately be weighed against improved surface and ground water quality, the benefits of which are not estimated in this analysis.

The analysis finds that there are significant variations in economic impacts among animal types and regions that are masked by national aggregate results (Figure 5). 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 if only CAFOs were required to meet nutrient standards (20 percent WTAM), 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 about the impacts of the nutrient application restrictions.

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 if only CAFOs meet nutrient standards and the WTAM is 20 percent, 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) when only CAFOs meet nutrient standards and the WTAM is 30 percent. This swing is attributed to the livestock supply-dampening and price-enhancing effects observed in the CAFO-only 20 percent scenario. When considering the net economic position of both consumers and animal producers, losses would be greater at lower WTAM levels, \$1.1 billion at a WTAM of 20 percent and \$0.66 billion at the 30 percent level.

This analysis also showed that requiring all AFOs to meet a nutrient standard would greatly increase the magnitude of national impacts (Figure 6). If there is a cost to operations other than CAFOs for meeting a nutrient standard, then they would not likely alter their manure management practices voluntarily and the estimated price changes would be lessened.

Conclusions

The willingness of cropland owners to accept manure was found to be an important variable in all three analyses. Impediments to using manure are well known. However, the willingness to accept manure has not been directly studied. Survey data indicate that less than 20 percent of cropland in major crops currently receives manure. Whether this reflects willingness-to-accept-manure is unknown. It might be that agricultural land currently receiving manure is on operations that have animals. A study of the willingness of cropland operators without livestock to use manure in place of commercial fertilizer, could provide a more accurate assessment of potential of land application as a primary manure disposal method. Further study could identify areas for education and extension that might reduce cropland operators' reluctance. Financial assistance through programs such as the EQIP could be used to encourage crop operators to use manure as a fertilizer and soil amendment. Animal producers might be able to increase willingness-to-accept manure by paying crop farmers to take manure; potential savings in manure hauling costs could make this worthwhile.

Advances in feed management may soon increase the options available to farmers for reducing nutrients in manure (CAST, 2002). While the ERS study examined how phytase use reduces phosphorus in manure and affects manure spreading costs under a P-based plan, other feed management options

include optimizing the amino acid content of feed, thereby reducing manure nitrogen. Optimizing feed for nitrogen excretion is more difficult to manage than for phosphorus, but it may play a future role in reducing excess nitrogen on animal farms. Further economic analyses would be useful in assessing the potential for such advances to reduce overall manure management costs.

The ERS analysis provides a first look at how alternative uses for manure might alleviate some of the costs of land application. Further assessment of the potential for manure products such as compost, fertilizer, and energy generation would provide additional information. Such markets, if developed, can be expected to affect the cost of meeting regulations, and thus the location and structure of animal operations.

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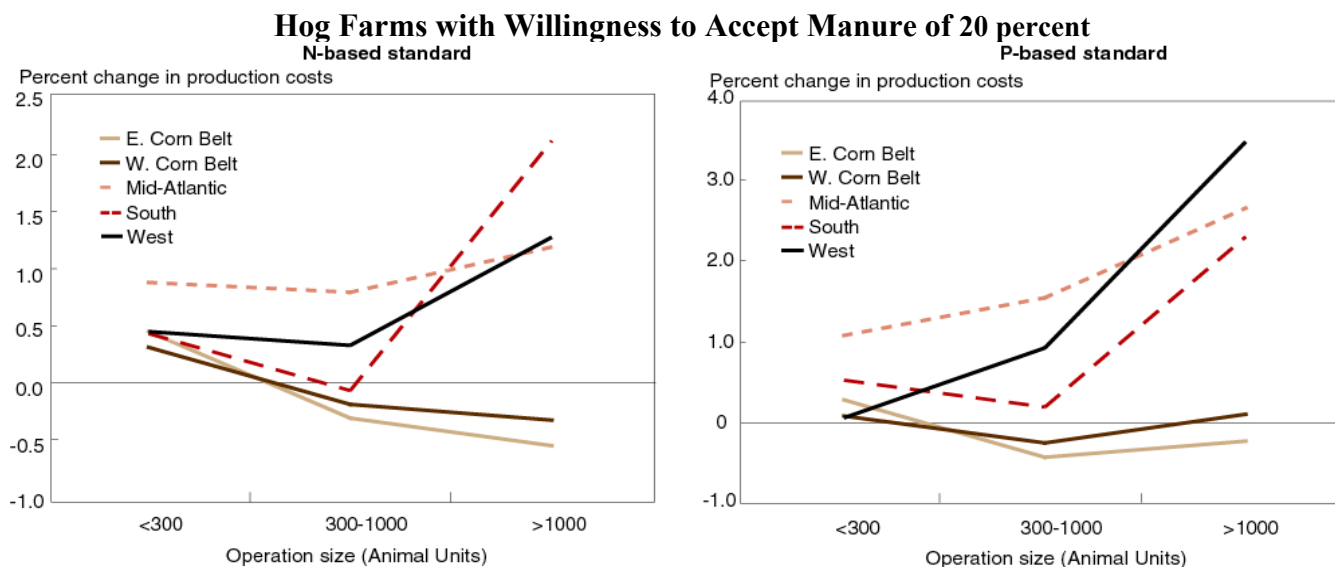
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Figure 1 Farm-Level Analysis: Focus on Hogs and Dairy

Increase in Production Costs to Meet Nutrient Standards Varies by Farm Size

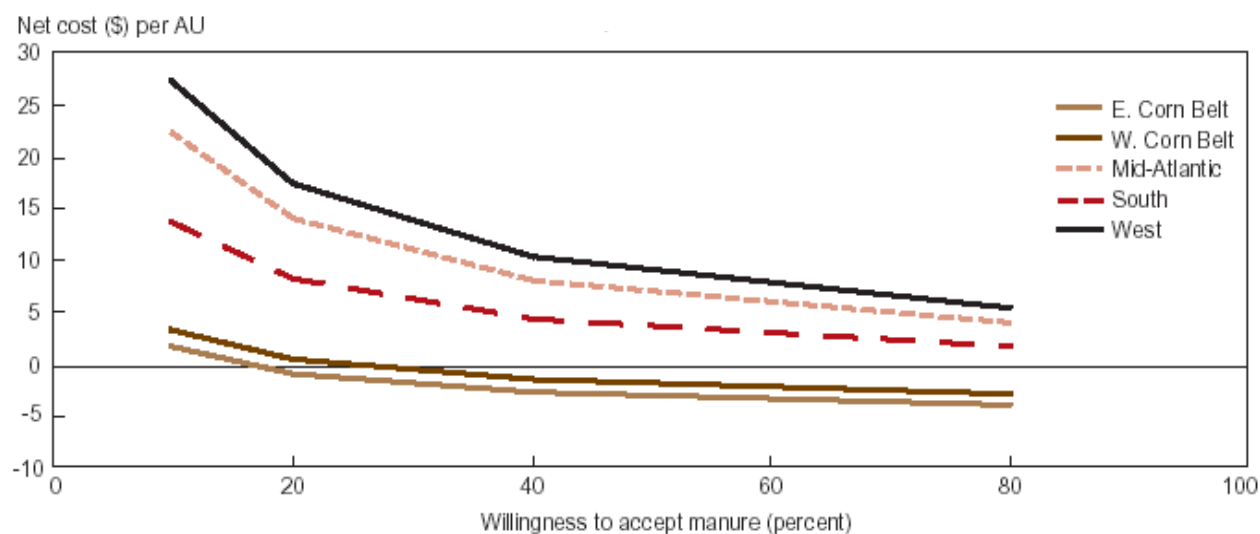


Source: Ribaud et al. (Economic Research Service, AER 824)

Figure 2 Farm-Level Analysis: Focus on Hogs and Dairy

Cost per Animal Unit (AU) Declines with Increased Willingness to Accept Manure

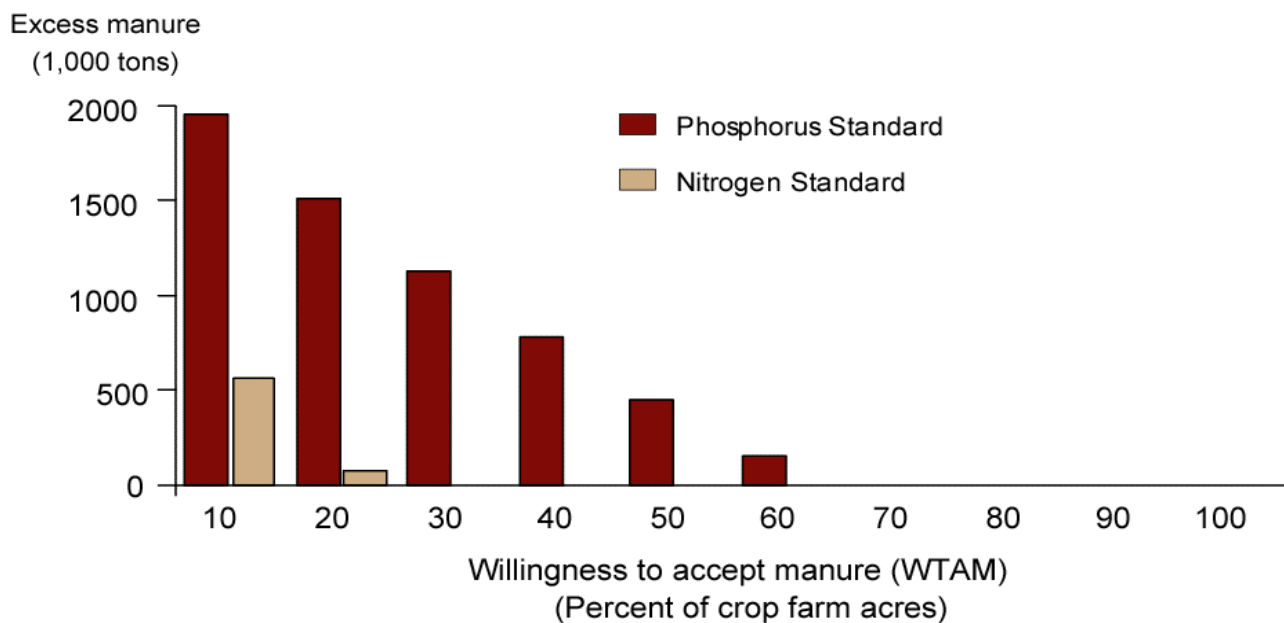
Hog Farms greater than 1,000 AU meeting a Phosphorus-Based Standard



Source: Ribaud et al. (Economic Research Service, AER 824)

Figure 3 Regional-Level Analysis: Focus on the Chesapeake Bay Watershed

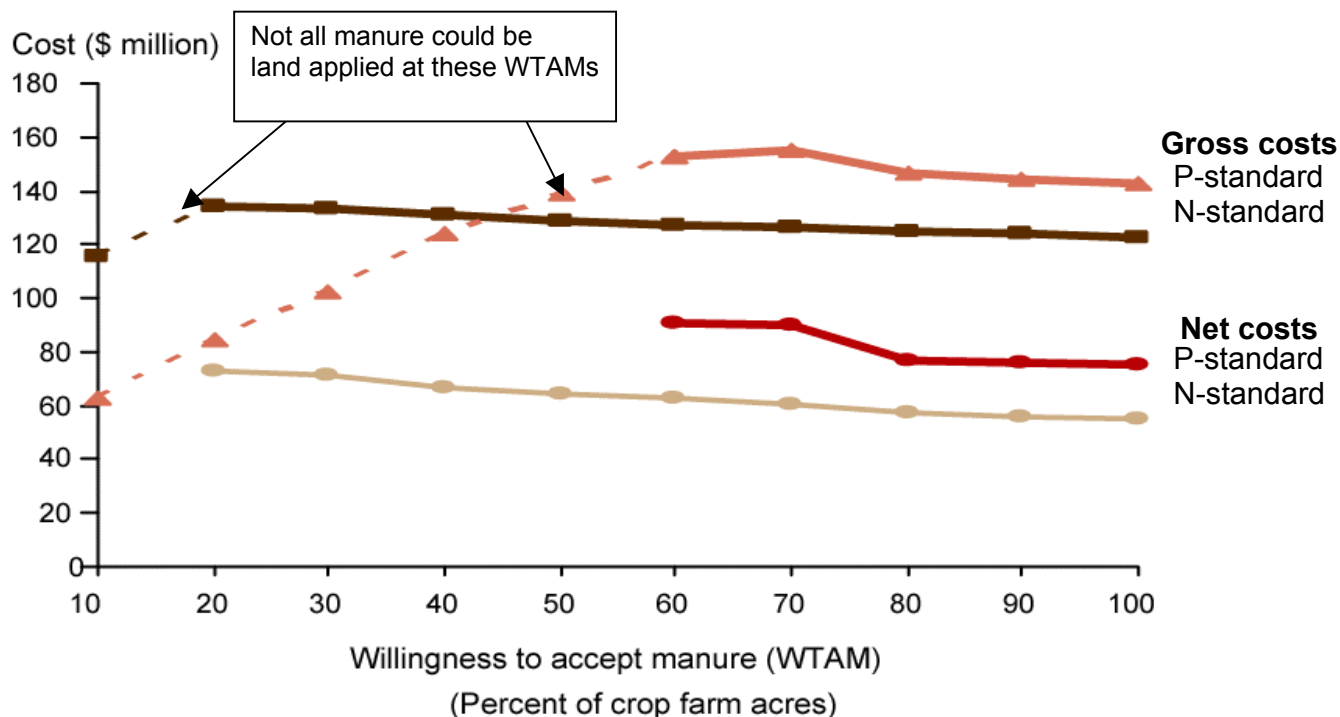
**Depending on Crop Growers' Willingness to Accept Manure (WTAM),
Not All Manure can be Land-Applied at Agronomic Rates**



Source: Ribaudo et al. (Economic Research Service, AER 824)

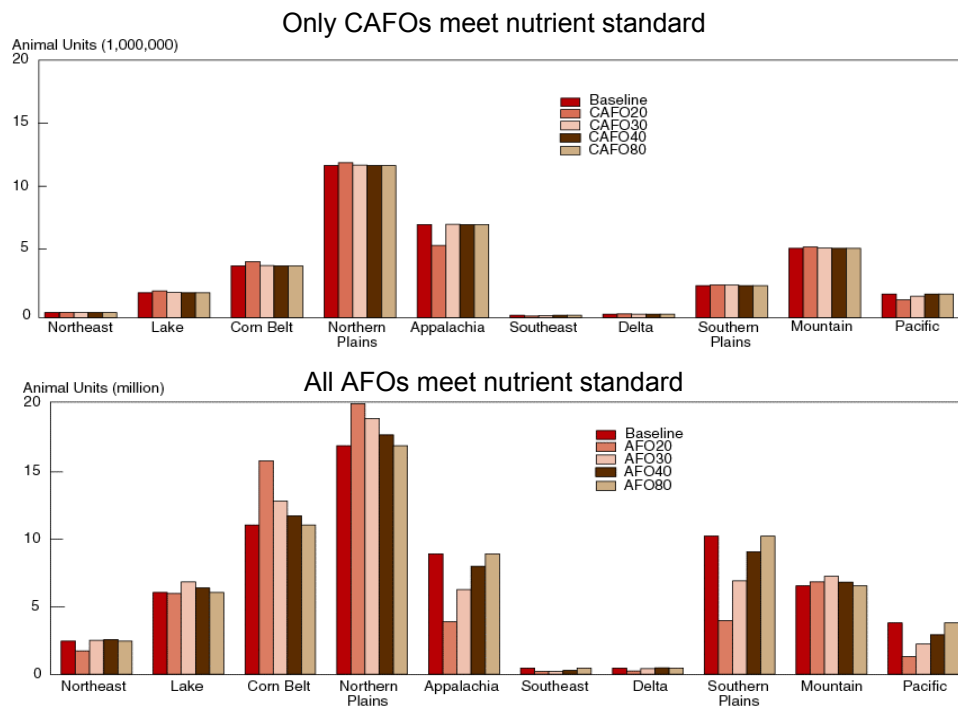
Figure 4 Regional-Level Analysis: Focus on the Chesapeake Bay Watershed

**Gross and Net Costs of Manure Disposal vary by Standard and
Willingness to Accept Manure**



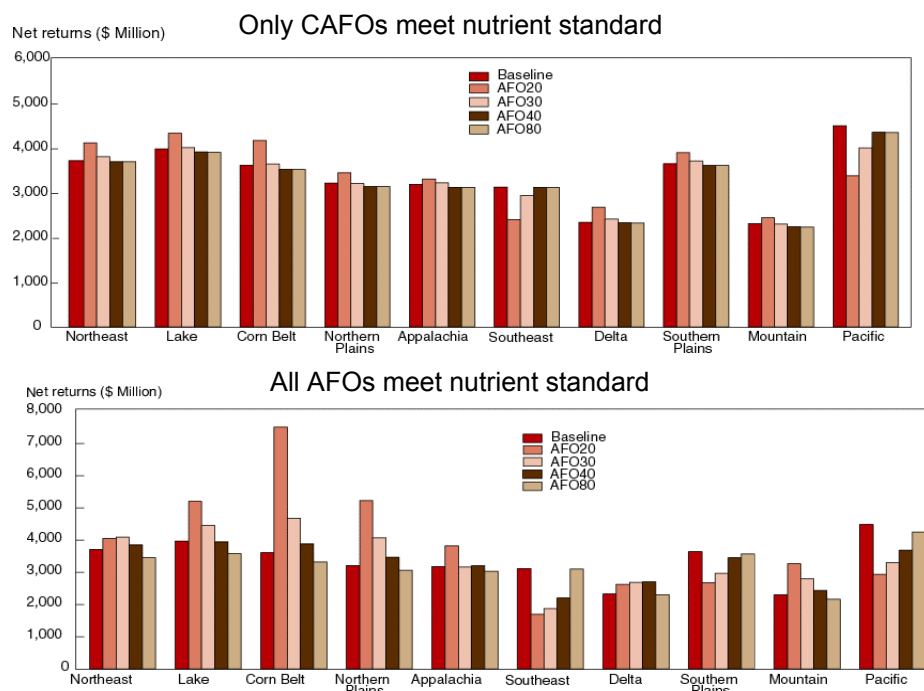
Source: Ribaudo et al. (Economic Research Service, AER 824)

Figure 5 National Analysis: Focus on Agricultural Markets
Animal Production by Willingness to Accept Manure, Standard,
Region, and Scenario



Source: Ribaud et al. (Economic Research Service, AER 824)

Figure 5 National Analysis: Focus on Agricultural Markets
Animal Producer Net Returns by Willingness to Accept Manure, Standard,
Region, and Scenario

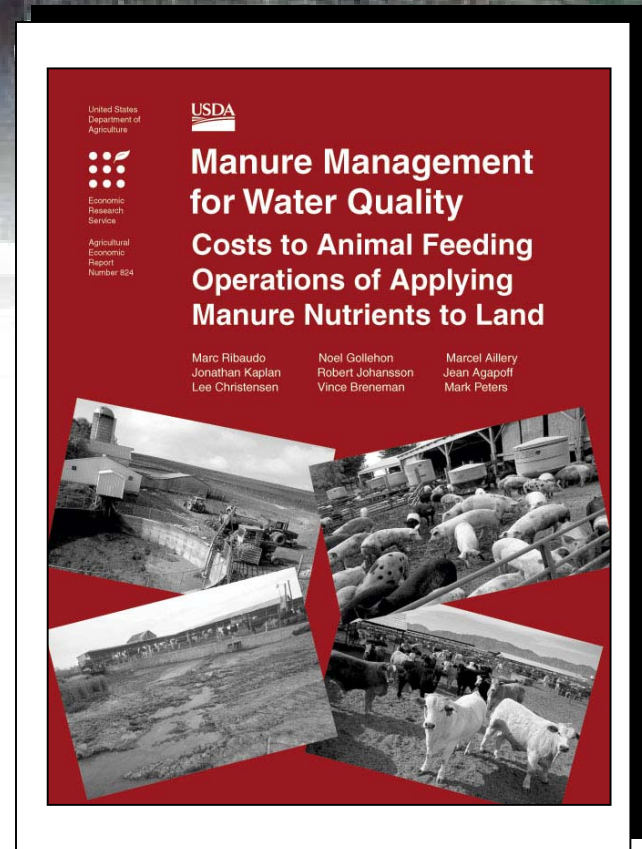


Source: Ribaud et al. (Economic Research Service, AER 824)

Manure Management for Water Quality Improvement

Costs to Animal Feeding Operations of Applying Manure Nutrients To Land

**Presentation by Noel Gollehon
Agricultural Outlook Forum
February 19, 2004
Arlington Virginia**



Background

- **USDA's National Performance Expectation for AFOs**
 - USDA Nutrient Management Policy
 - Comprehensive Nutrient Management Planning Technical Guidance
- **U.S. EPA revised CAFO Regulations**

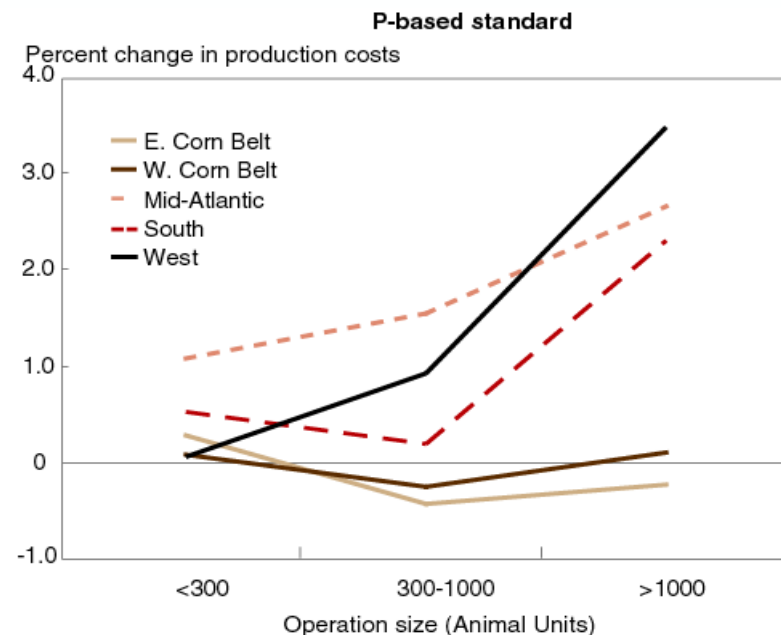
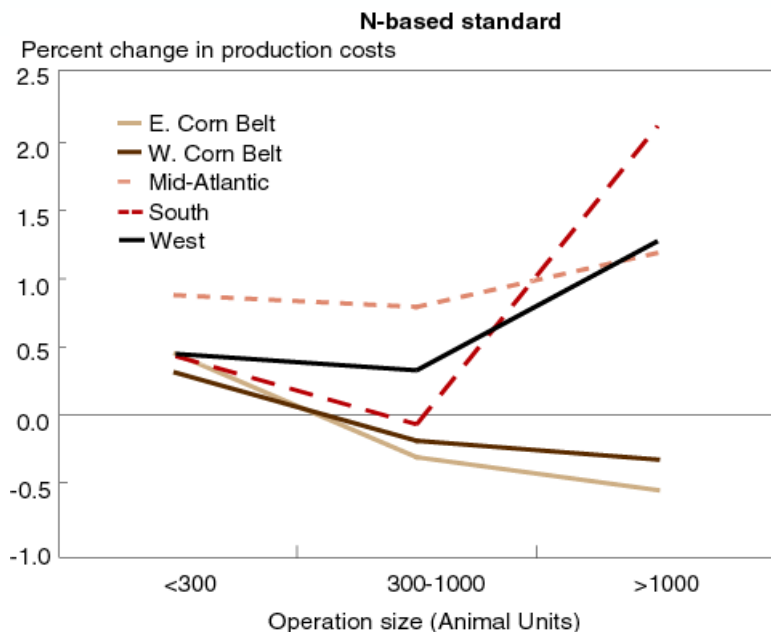
Focus of the ERS Report

- Analyzes factors that influence the cost of applying manure to land
- Analyzes aggregate supply and price effects of regulations and guidelines
- Includes a range of scopes
 - Farm-level analysis
 - Regional-level analysis
 - Sector-level analysis

Farm Level Analysis: Focus on Hogs and Dairy

Increase in Production Costs to Meet Nutrient Standards Varies by Farm Size

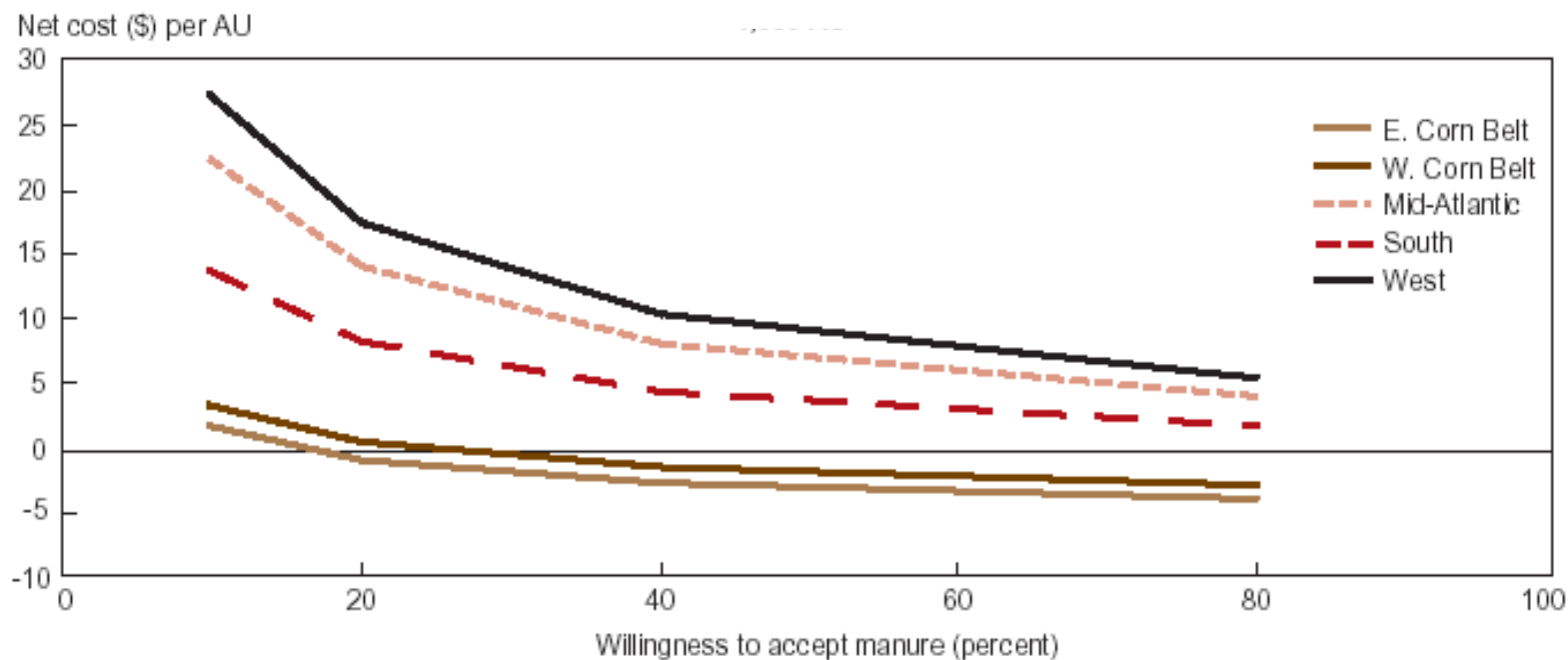
Hog farms with a Willingness to Accept Manure (WTAM) of 20 Percent



Farm Level Analysis: Focus on Hogs and Dairy

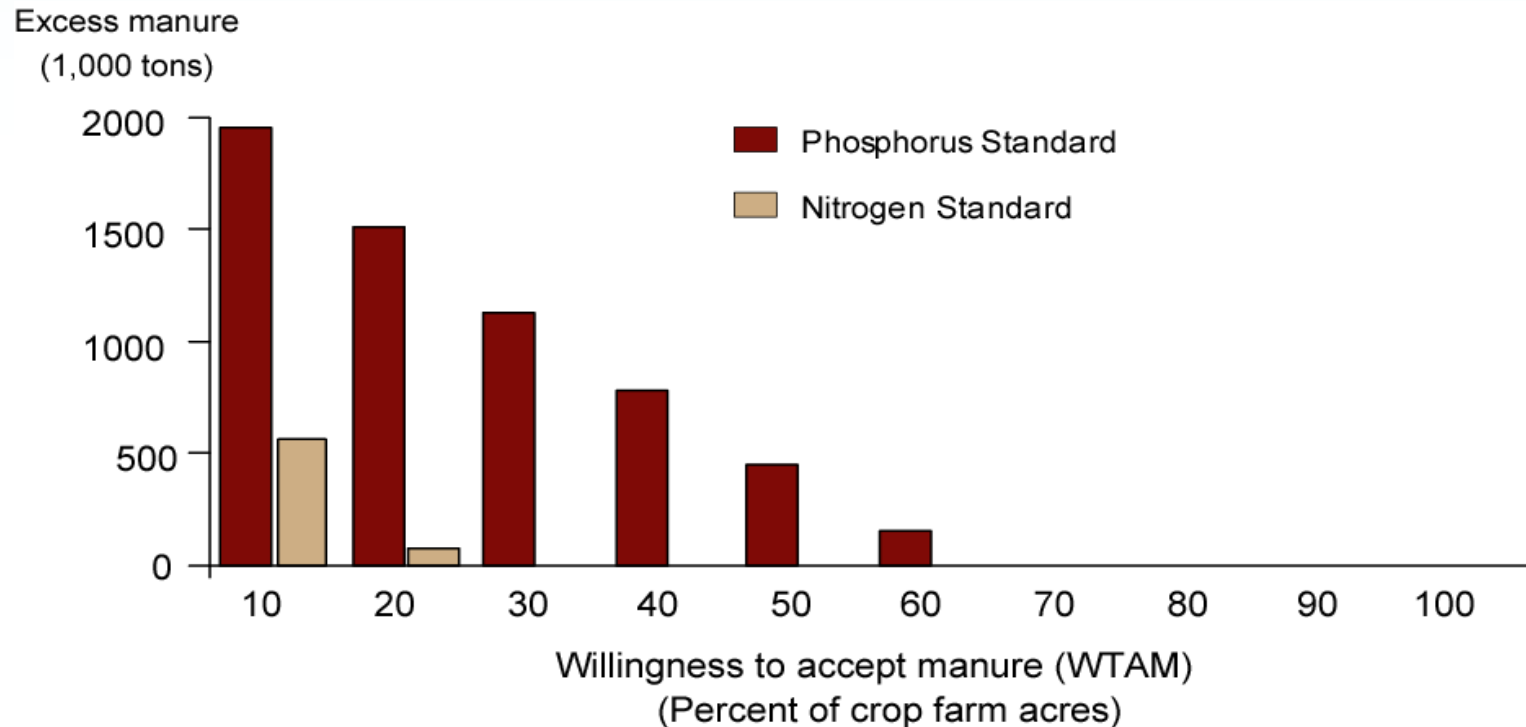
Cost Per Animal Unit (AU) Declines with
Increased Willingness to Accept Manure

Hog Farms > 1,000 AU meeting a Phosphorus-Based Standard



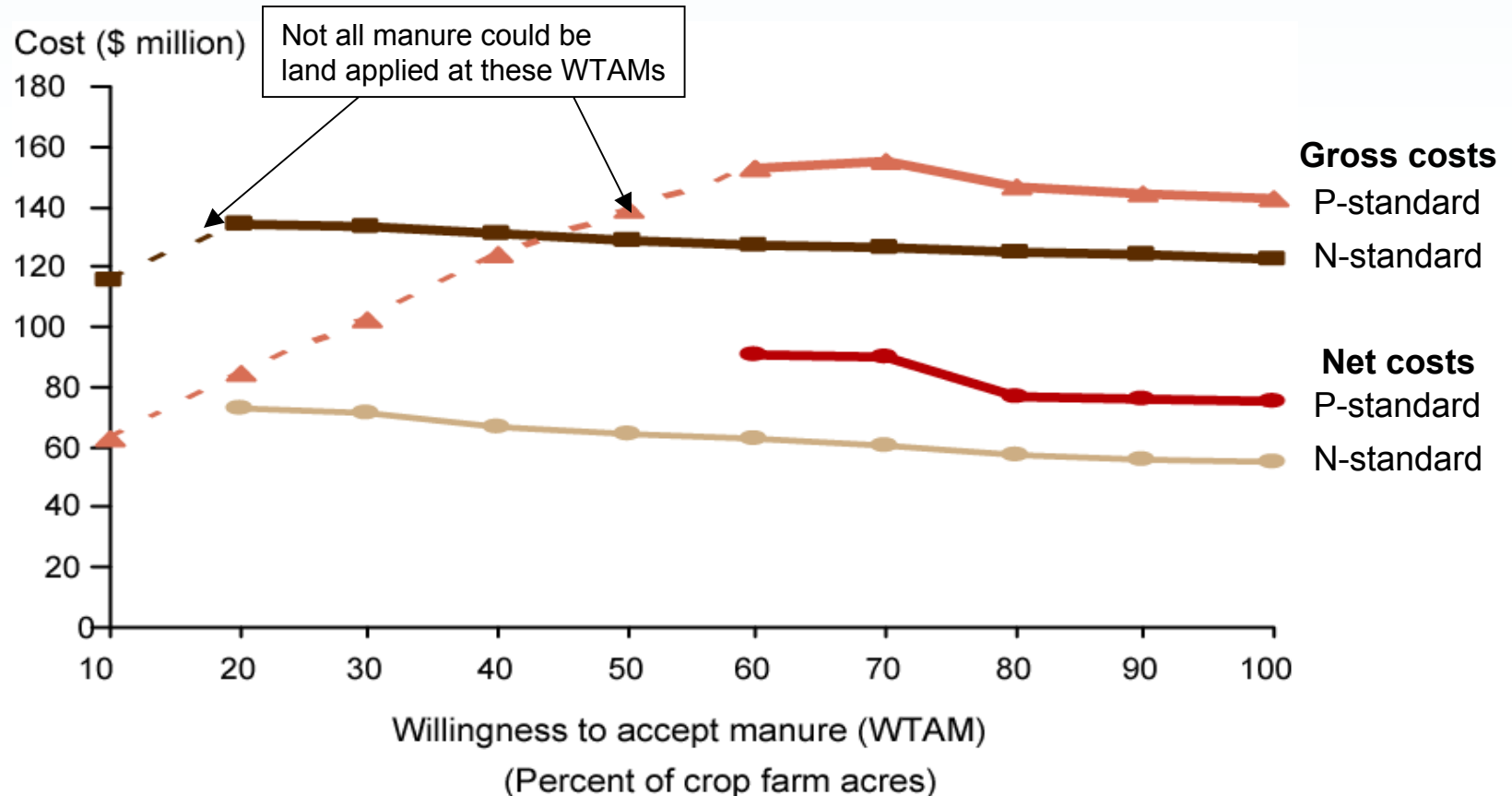
Regional Analysis: Focus on the Chesapeake Bay Watershed

Depending on crop growers' WTAM, not all manure
can be land-applied at agronomic rates



Regional Analysis: Focus on the Chesapeake Bay Watershed

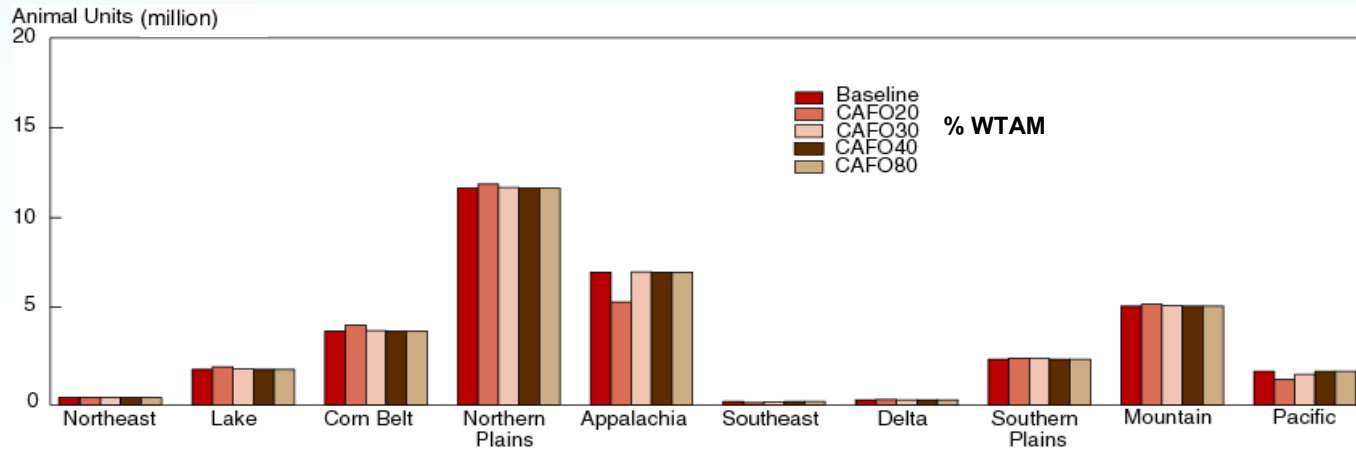
Gross and net costs of manure disposal
vary by standard and WTAM



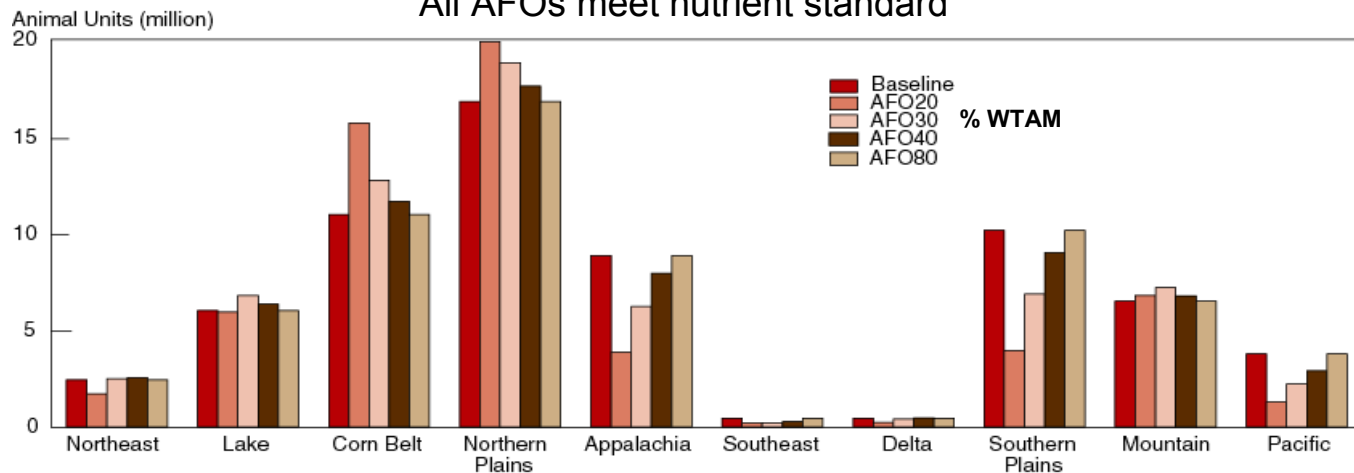
National Analysis: Focus on Agricultural Markets

Animal production by WTAM and region

Only CAFOs meet nutrient standard



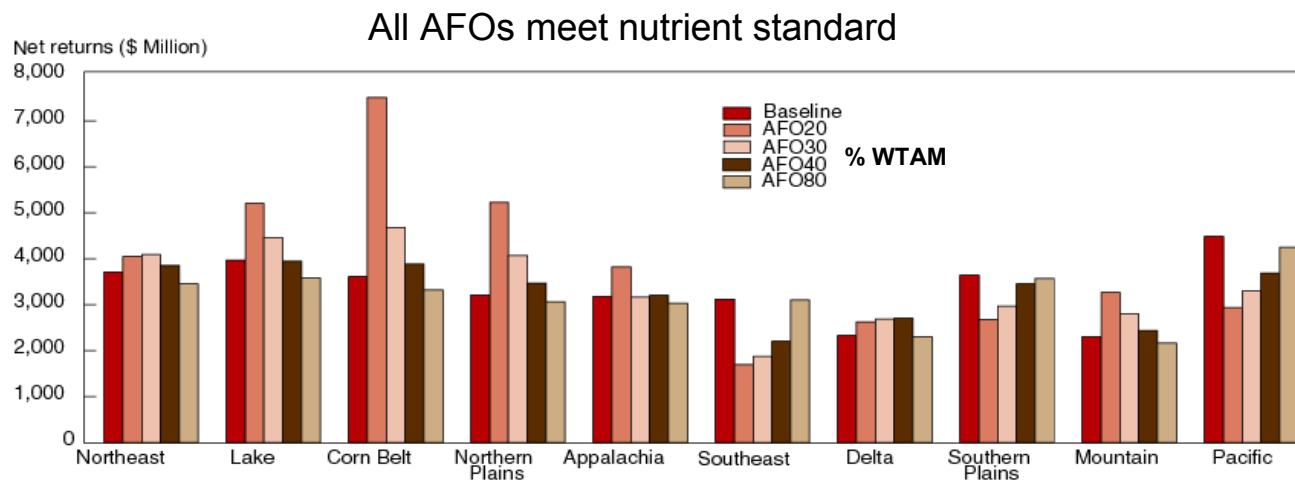
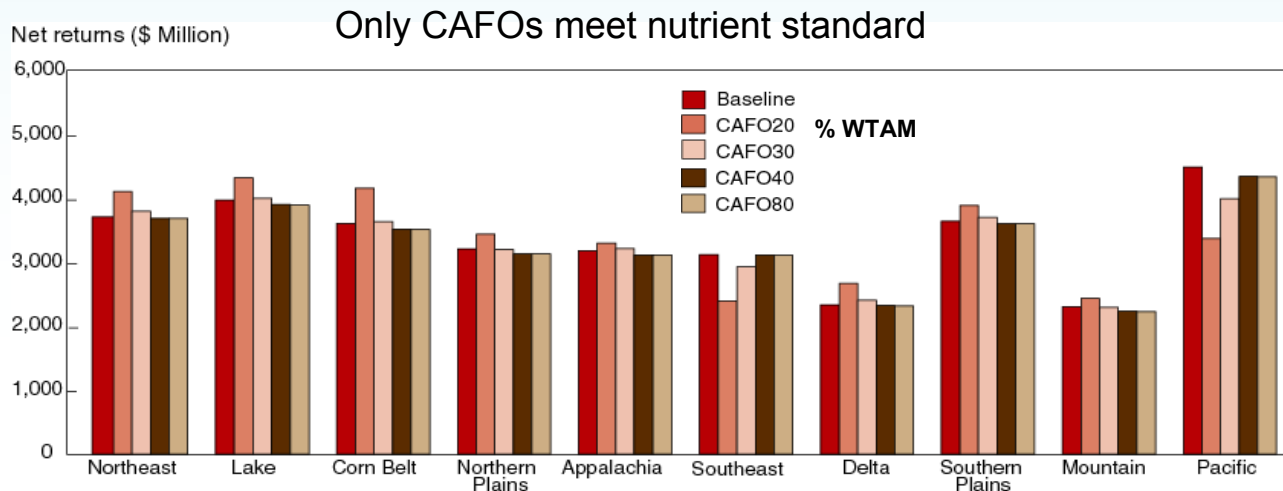
All AFOs meet nutrient standard



National Analysis:

Focus on Agricultural Markets

Animal producer net returns by WTAM and region



Implications for USDA

Manure management costs can be decreased by increasing crop producer willingness to accept manure, through:

- Research
- Education
- Financial assistance
- Community-based programs to foster cooperation between animal producers and crop producers

Implications for USDA

- Land disposal costs can be reduced by finding other uses for manure:
 - Fertilizer products
 - Energy
 - Soil amendments
- Feed management research, technical transfer, and other assistance can reduce:
 - The nutrient content of manure
 - The amount of land needed for spreading manure
- Farm and regional characteristics can be considered in conservation program priorities and decisions

Manure Management for Water Quality Improvement

Costs to Animal Feeding Operations of Applying Manure Nutrients To Land

