Economic Impacts of EPA's Manure Application Regulations on Dairy Farms in the Southwest Region.

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ABSTRACT

We estimate that EPA's CAFO final rule on manure application would have different impacts on dairy farms in the region, assuming that the farms would maintain the same herd size and same crop production practices. Some farms in the region would be able to comply it on their current land base, but other would need to lease additional land for land application of manure. Less than 30 percent of those affected farms would have a lower farm income. Most of these affected farms could have no income reduction or a higher income as a result of reduced feed cost from expanding homegrown feed production.

Key Words: dairy farms, land application, manure regulations

Livestock industries in the U.S. have undergone dramatic structural change in recent years. Technical innovations, changes in production system and specialization have led to an expansion of large concentrated livestock operations. The environmental effects of waste management practices from those large concentrated livestock feeding operations are an increasing source of public concern (Litke; Innes; Metcalif; Kaplan, Johansson, and Peters). In response to this concern, EPA (1999) proposed changes to the current National Pollutant Discharge Elimination System (NPDES) permit regulations and to the Effluent Limitation Guidelines (ELG). These changes include redefining the concentrated animal feeding operations (CAFOs) subject to NPDES permit regulation, and respecifying ELG for the permit, including handling and land application of manure.

EPA's final rule (December 15, 2002) defines a dairy operation as a large CAFO if it has more than 700 mature dairy cows in the operation and as a medium-size CAFO if it has between 200 and 700 dairy cows and meets certain conditions. Any operation regardless of size can be designated as a CAFO if the permitting authority inspects the operation and finds that it is polluting surface waters. All large CAFOs are subject to the NPDES permit regulation. Medium-size CAFOs are subject to the NPDES permit only if the operation has a man-made ditch or pipe that carries manure or wastewater into surface waters or if animals come into contact with surface waters running through their confinement area. This new CAFO definition, which lowers the minimum number of dairy cows in a regulated operation from over 700 to over 200 cows may increase the number of dairy farms under regulation.

Under EPA's new ELG, all new and existing CAFO operators need to develop and implement nutrient management plans that address land application area and are based on the most limiting nutrient. CAFO operators may need to follow the phosphorous (P)-based nutrient management plan (NRCS, 2001), in addition to the existing N-based plan. Under the P-based plan, CAFOs must restrict manure application to provide only the amount of P needed by crops, or restrict manure application to supply the nitrogen (N) needed by crops in areas of low P. These changes of guidelines could increase manure application costs and reduce profits of CAFO dairy farms.

Objective

The primary objective of this study is to assess the economic impacts of the new EPA manure regulations on dairy operations defined as CAFOs in the Southwest region, which includes the states of California, Arizona, New Mexico, Texas, and Oklahoma. In 2000, these states had 6 percent of U.S. dairy farms and produced 43 percent of U.S. milk production. More importantly, these states had 48 percent of medium and large dairy farms (with more than 200 cows) in the U.S., which produced 31 percent of U.S. milk.

This paper addresses the following questions: How many additional dairy farms in the Southwest would be subject to the new EPA rule, which reduces the minimum number of mature cows in a CAFO from the current level of over 700 to over 200 when certain conditions are met? How many of those newly regulated farms would have to arrange for additional land for land application of manure and what acreage would be needed? What would be the average cost per farm and the cost per cwt. of milk sold to comply with the new land application restrictions? What would be the marginal value (shadow price) to the farm from reducing the amount of manure? What would be the short-run and long-run income losses, under various application restriction scenarios? Data used came from a national dairy survey completed in the USDA's 2000 Agricultural Resources Management Survey (ARMS).

Assessment Models

This study used an individual whole-farm analysis to estimate the economic impacts of the new regulations on surveyed dairy farms. The dairy operation of each affected farm was modeled using the production characteristics reported in ARMS. We used Heimlich's modeling framework, which included herd-feeding operations, to design a linear programming model for each dairy farm in the survey. A whole-farm model was constructed, assumed that the farm would maintain the same herd size and the same crop production practices under the proposed restrictions. Recommended levels of roughage and concentrates in the feed ration either grown on-farm or purchased off-farm, were used to model the herd-feeding operation. (A complete description of the model is available on request).

Objective Function

We assume that the dairy farm operator will maximize the net return from milk and crops sales, subject to the amount of manure produced on the farm and the available crop acreage on the farm for manure application. The net return was defined as residual return to management, land ownership, and the capital investment of the dairy operation (excluding fixed costs for crop production). The objective function was subject to the following restrictions.

Acreage Restriction. The constraint ensures that the sum of acres used to grow the different crops is less than or equal to the total number of acres available on the farm and additional land leased for manure application.

Manure Use Restriction. This constraint ensures that all manure produced on the farm is spread on crops.

Per-acre Nutrients Required by Crops. The constraint requires that the applied amount of each nutrient (N, P, and K) per acre from manure and supplemental commercial fertilizer do not exceed the amount needed by the crop.

Nutrient Application Restrictions. EPA's proposed rule will require that per-acre amount of P or N from applied manure cannot exceed the per-acre amount of the nutrient needed by the crop.

Manure Application Cost. Manure application costs include the irrigation cost to spray lagoon liquid and field application and hauling costs to spread solid manure. These costs only account for manure that remains on the farm.

Herd Feeding Requirements (NAS). The ration fed to the dairy herd provides nutrients for milk production and herd maintenance, including net energy, crude protein, and crude fiber from roughage. These nutrients come from homegrown crops or purchased feeds. The dairy operator ensures that the ration provides the recommended daily minimum requirements for the herd. The following constraints ensure that feeding requirements for net energy, crude protein, and crude fiber are met on annual basis: (1) the annual supply of net energy from homegrown crops and purchased feeds is greater than or equal to the required net energy of the herd; (2) the supply of crude protein from homegrown crops and purchased feeds is greater than or equal to that required by the herd; (3) the supply of dry matter in the ration from purchased feeds and homegrown crops is less than or equal to 4 percent of the animal weight; and (4) the supply of crude fiber is at least 17 percent of the roughage in the ration.

Data and Assumptions

In this research, we used data from the 2000 ARMS survey to obtain or estimate key parameters for the model. The parameters include crop yields, crop acres, number of animal units (AU) (where one AU is assumed to be 1000 pounds of live weight), quantity and price of milk produced, amount of manure produced, minimum required amount of net energy, crude protein, and crude fiber, and maximum amount of roughage per AU. Several key assumptions were made in this analysis.

The operation maintained the same herd size, type of dairy operation, and manure storage and application system regardless of manure application restrictions. We assumed that the operation was able to lease additional land adjacent to the farm to utilize manure to meet the restrictions on manure nutrient application, and cropped and harvested this land the same as on existing land. The state's cash rent paid for additional land in the region was used when the actual rent was not reported in the survey (NASS, 2000). Crops grown on the farm were limited to the type of crops grown on the surveyed farm in 2000. Surveyed yields of these crops were used to determine the amount of nutrients needed for crop growth in complying with the restrictions. The same yields were assumed for crops grown on both manured and non-manured acres.

All farms using a similar manure system were assumed to have the same coefficients for nutrient contents in manure, amount of nutrients needed by crops, dairy daily nutrient requirements, and dairy nutrients supplied by crops.

The composition of the herd (number of lactating and dry cows, replacement heifers, and bulls on each farm) determines the amount of manure the farm must spread on cropland annually and the amount of N and P available for crop use. The amounts were adjusted according to the proportion of solid manure and liquid manure produced on the farm, and the nutrient losses due to the field application method used (Sutton, Joern, and Hubber, 1994). The determination of the amounts of nutrients needed by crop was also based on the average crop yield reported (Sutton, Joern, and Huber, 1994).

The determination of the annual amount of net energy, crude protein, minimum crude fiber, and maximum dry matter per AU for each farm was based on the herd composition and the quantity of milk produced. For purchased feed, the amount of dry matter for one Mcal purchased was 0.96 lbs., based on purchased corn grains (NAS, 1978).

Manure application costs include the irrigation cost to spray lagoon liquid, and hauling costs and field application costs to spread solid manure. An irrigation cost of $0.30 per 1000 gallons was assumed, using a central pivot spray-irrigation system (Dorn, O'Brien et.al.). The field application of solid manure includes loading manure from the storage and spreading manure on the field. Hauling cost was $1 per ton per mile and field application cost was $4.80 per ton (Outlaw, Puris, and Miller). A non-linear function was used to estimate total hauling miles.

Crop market prices in 2000 for the Southwest region were $1.89/bu for corn, $4.75/bu for soybeans, $2.54/bu for wheat, and $1.75/bu for sorghum (USDA, 2000). Fertilizer nutrient prices used were $0.15/lb for nitrogen, $0.29/lb for phosphate, and $0.15/lb for potash based on April prices (USDA, 2000). These fertilizer nutrient prices include application costs.

Crop production costs excluding fertilizer and land ownership costs were $228/ac for corn, $156/ac for soybeans, $107/ac for wheat in 1999 (ERS, 2001), $10/ton for corn silage, $38/ton for alfalfa hay, and $45/ac for Bermuda-grass hay (Texas A and M).

The costs for purchased feeds were based on the estimated nutrient prices of feeds. The estimate prices for net energy was $0.0284/Mcal, for crude protein $0.1328/lb, and for crude fiber $0.01642/lb. These estimates were obtained by a regression analysis using feed purchased data from the 2000 ARMS and using the feed nutrient composition data from the National Academy of Science.

Scenarios

One baseline scenario, one no- restriction scenario, and two restriction scenarios were specified for assessing the farm-level impacts:

***Baseline*:** Manure application rate was unrestricted and manure was applied to the same number of acres reported by the survey farms. This simulated the actual land application of manure by surveyed farms in 2000.

***No-restriction*:** The manure application rate and the number of acres receiving manure were not restricted. This scenario simulated the land application of manure if the number of acres receiving manure in the baseline scenario was not fixed.

P-restriction: Manure application rate was restricted not to exceed the phosphorous needs of an individual crop and number of acres receiving manure was not restricted.

N-restriction: Manure application rate was restricted to not exceed the nitrogen needs of individual crops and number of acres receiving manure was not restricted.

Results of the Analysis

There are 51 surveyed medium farms and 29 surveyed large farms in the region that would be affected by the proposed regulation. Of these farms, only 26 of medium farms and 13 of large farms were used in the analysis. Most of the affected farms excluded from the analysis had all their manure hauled away from the farm. Three of the surveyed farms used slurry manure storage systems. Because the number of observations for this technology was so small they were not included in this study. Each of the 29 medium and 13 large farms was analyzed individually for each scenario and the results are summarized in Tables 1 and 2. Using information in Tables 1 and 2, the impacts can be assessed by comparing the results of the baseline scenario with the results of two restriction scenarios. The baseline simulated the actual land application of manure on number of acres reported by farms in 2000. Results in Table 1 show that 35 percent of feed consumed by the medium farms was from homegrown crops. This result is consistent with the findings reported for the farms in the region in 1996 (Short). Furthermore, there is a larger difference in net returns between the baseline and no-restriction scenario than in the differences in net returns comparing the baseline and the N and P restriction scenarios.

Additional Affected Farms

The ARMS survey data were used to estimate additional affected farms. A total of 872 dairy farms responded to the ARMS survey, representing 71,331 U.S. dairy farms when expanded by survey weights. The previous EPA regulations (1976), requiring that farms over 700 cows obtain a NPDES permit, would affect 761 dairies in the Southwest region, or about 1.1 percent of dairy farms in the nation. The new CAFO definition (USEPA, 2002) would also affect large farms. In addition, the new CAFO definition could also require that medium farms over 200 and less than 700 cows obtain a permit, thereby affecting an additional 2,087 farms or about 2.9

percent of U.S. dairy farms. Among these farms, EPA estimates that only 18 percent of them would be classified as CAFO under the man- made ditch and the direct contact conditions. The number of additional medium farms then is estimated to be 376 (2,087 x 0.18). This number is consistent with the EPA's estimated 346 medium farms in the Central and the Pacific regions (USEPA, 2002). We assumed that the analyses below would be applicable to those CAFOs defined by EPA (2002).

Additional acres needed

Table 3 shows the additional leased acres that would be needed to comply with a N-restriction or a P-restriction by the affected farms. The results indicate that both N- and P- restrictions would impact some dairy farms. For the medium dairy farms, the N-restriction would affect 38 percent of the farms, and the P-restriction would affect 42 percent. For the large dairy farms, the N-restriction would affect 32 percent of the farms, while the P-restriction would affect 10 percent. This reduction is caused by those farms needing less acreage to grow sorghum silage under the P-restriction than under the N-restriction. The average additional acres needed and the associated costs for the affected medium and large farms also are shown in Table 3.

Average compliance costs

To comply with the restrictions, the dairy farm may have to expand manured acres in crops that may cause their farm income to be reduced or increased, depending on the price of purchased feed. An expansion of manured acres increased manure application cost. However, an increase in crop production from the expanded manure acres would increase the supply of homegrown feeds and reduce the cost of purchased feeds. A positive (negative) compliance cost indicates that the savings from the feed cost plus the returns from the sale of crops is less (greater) than the costs to produce crops on the expanded manured acres. The average compliance cost for the medium farms was -$6,663 (an income gain) under the N-restriction, and -$2,024 under the P-restriction (Table 4). About 9 percent of the surveyed dairy farms would have a net income loss under the N-restriction, while about 19 percent would have a net income loss under the P-restriction. The average compliance cost for the large farms was $5,516 under the N-restriction. This cost reduced to $3,217 for the large farms under the P-restriction, because of the net savings of purchased feed costs from expanded acreage. About 29 percent of the large farms would have a net income loss under the N-restriction, while about 9 percent would have a net income loss under the P-restriction. The result that the affected farms could gain by expanding crop production was based on the assumption that the farm would be able to lease additional land adjacent to the farm at the current cash rent to grow crops to comply with the restrictions. The validity of this assumption requires a further investigation. Furthermore, there are many factors that could limit the expansion of crop production in the region. For example, higher cost to acquire additional irrigation water for crop production in that arid region could cause the expansion of crop feed crop production to be unprofitable.

The average compliance cost per cwt of milk sold by the medium and large farms were negative, indicating an income gain under both N- and P-restrictions. Although the average gains were relatively small, the range of the compliance cost was relatively large (Table 4).

Marginal Costs (Shadow Prices) of Manure

Table 5 shows the average marginal cost of manure for surveyed dairy farms under various application scenarios. For the medium-size dairy farms, the average marginal cost was negative under baseline scenarios. The negative marginal cost indicated that the last unit of manure applied was valuable to the farms. This value reflects that the assumed cost to spray manure using a central pivot irrigation system ($0.30 per 1000 gallons of manure) is smaller than the fertilizer value (more than $1.50/1000 gallons). The value was reduced but still negative when the farms complied with the restriction. For the large dairy farms, the average marginal cost was also negative, but became positive when the farms complied with restriction.

Not all the dairy farms would gain from the last unit of manure applied to the crop. Under the N-restriction, about 60% of the medium farms and 81% of the large farms would profit from the last unit of manure applied. Under the P-restriction, about 44 % of the medium farm and 81 % of the large farms would profit from the application.

Net Returns to Dairy Operations

Table 6 shows two sets of average net return values: net returns to operation (NETO), which equals the return from milk sold less operating costs, and net return to the farm (NETF), which equals the return from milk sold less operating and overhead costs for various manure application restriction scenarios. NETO values provide snap-shots of the short run in year 2000, while NETF values provide a long run financial situation had the farms been obliged to comply with the restrictions. In the table, those baseline values were the averages calculated from the individual surveyed farms. Those values under each restriction were the average values under each restriction scenario. Both medium and large dairy farms, on average, had positive NETO and negative NETF. Both farms could improve their NETO and NETF by better utilizing their manure when the restrictions were imposed. Under the P-restriction, however, the number of the large farms with negative NETF could increase from 60 % to 62%.

Summary and Conclusions

EPA's CAFO final rule changes the NPDES regulation. The changes include redefining concentrated animal feeding operations (CAFOs) and specifying permit requirements for land application of manure. This study assessed the economic impacts of these changes on dairy farms in the Southwest region using data from the 2000 ARMS. The Southwest includes California, Arizona, New Mexico, Oklahoma, and Texas. Major findings of this study are:

(1) EPA's rule would make an estimated 376 medium dairy farms subject to the proposed new regulations in the Southwest region.

(2) Under the rule, about 38 percent of the medium-sized farms would need additional land to spread manure to comply with the N-restriction, and 42 percent would need more land to comply with the P-restriction. About 32 percent of the large farms would need additional land to spread manure to comply with the N-restriction, and 10 percent of large farms would need additional land to comply with the P-restriction. The large decrease is predicted to occur because the large farms growing corn silage or sorghum silage would require fewer acres to comply with the P-restriction than with the N-restriction.

(3) About 9 percent of the medium farms would have lower net income under the N-restriction compared to 19 percent under the P-restriction. About 29 percent of the large farms would have net income reduced under the N-restriction compared to 9 percent under the P-restriction.

(4) About 60 percent of medium farms would have lower net income from the last unit of manure that they applied under the N-restriction, compared to 44 percent under the P-restriction. About 81 percent of the large farms would have lower net income under either the N or the P-restriction.

(5) The rule would not cause an increase of number of medium farms moving from positive net income group to the negative net income group in both short and long

run. The rules also would not cause any increase of number of large farms moving to the negative income group in the short run, but would cause a 2 percent of large farms moving from positive income group to negative income group in the long run.

In conclusion, EPA's CAFO final rule on manure application would have different impacts on dairy farms in the region, assuming that the farms would maintain the same herd size and same crop production practices. Some farms in the region would be able to comply it on their current land base, but other would need to lease additional land for land application of manure. Many those affected farms had low crop yields (lower than the average crop yields in the region (NASS) and could significantly reduce the need of additional acres to spread manure by improving their crop yields. Less than 30 percent of those affected farms would have a lower farm income, while 70 percent of those affected farms could have no income reduction or a higher income as a result of reduced feed cost from expanding homegrown feed production. This result was based on the assumption that the affected farm would be able to lease additional land adjacent to the farm at the current cash rent to grow crops to comply with the restrictions. The validity of this assumption requires a further investigation. Furthermore, there are many factors that could limit the expansion of crop production in the region, for example, higher cost to acquire additional irrigation water in that arid region.

References

Dorn , W. T. *Annualized Cost of Irrigation System. Extension educator, Lancaster County Nebraska*. http://lancaster.unl.edu/ag/crops/irrgcost.pdf. 2001

Economic Research Service, Costs and Return: Crops. http//www.ers.usda.gov/data/costs and returns. Accessed 3/10/2001.

Heimlich, R. E. (1982). *Phosphorus Reduction and Farm Income: Modeling Efficient Response to Phosphorus Loading Constraints on Vermont Dairy Farms.* Technical Report, Economic Research Service, United States Department of Agriculture.

Innes, R. "The Economics of Livestock Waste and Its Regulation." *American Journal of Agricultural Economics* 82 (February 2000): 97-117.

Kaplan, J. D., R. Johansson, and M. A. Petters. Proposed Requirement for Manure Nutrient Requirement: Potential Sector Impacts. Agricultural Outlook, Economic Research Service/USDA, April 2002.

Leatham, D. J.,J. F. Schmucker, R.D. Lacewell, R. B. Schwart, A. C. Lovel, and G. Allen. "Impact of Texas Water Quality Laws on Dairy Income and viability." Journal of Dairy Science. 75:2846-2856. 1992.

Litke, D.W. *Review of Phosphorus Control Measure in the United States and their Effects on Water Quality*. Geological Survey, U.S. Department of Interior, Water-Resources Investigations Report 99-4007, 1999.

McSweeney, W. and J. Shortle. (1989). Reducing Nutrient Application Rates for Water Quality Protection in Intensive Livestock Areas: Policy Implications of Alternative Producer Behavior. *Northeastern Journal of Agricultural and Resource Economics* 10 (2): 1-11.

National Academy of Sciences. *Nutrient Requirements of Fairy Cattle*. Fifth revised edition, Washington, DC. 1978.

National Agricultural Statistical Service. U.S. Department of Agriculture. *Agricultural Cash Rents*. Sp Sy 3(99). July 2000.

National Agricultural Statistics. U.S. Department of Agriculture. *Agricultural Prices*. 2000.

Natural Resources Conservation Service, *Comprehensive Nutrient Management Planning: Technical Guidance*. U. S. Department of Agriculture, December 1, 2000.

Metcalfe, M. (2000). "State Legislation Regulating Animal Manure Management." *Review of Agricultural Economics* 22 (2): 519–532.

Outlaw, J., A. Purvis, and J. Miller. *An Evaluation of Dairy Manure Management Economics*. AFPC Policy Research Report 95-2, department of Agricultural Economics, Texas A&M University, 1995.

O'Brien, Danny H. Rogers, Freddie Lamm, and Garry Clark. *Economic Comparison of SDI and Central Pivots for Various Field Sizes.* Kanasas State University Agricultural Experiment Station and Cooperative Extension Service. 1997

Pratte, S., R. Jones and C.A. Jones. (1997). *Livestock and Environment: Expanding the Focus.* TIAEA PR96-03. Tarleton State University, Texas.

Short D. Sara. *Structure, Management, and Performance Characteristics of Specialized Dairy Farm Businesses in the United States*. Agricultural Handbook Number 720. Economic Research Service. 2000.

Sutton, A.L., D.D. Jones, and D.M. Huber. (1994). *Animal Manure as a Plant Nutrient Resource*. ID-101, Purdue University Cooperative service, May 1994.

Texas A &M Extension Crop and Livestock Budgets. http//agecoext.tmu.edu/budgets/list.htm.

U.S. Department of Agriculture. National Agricultural Statistics Service. Dairy Production Practices and Costs and Returns Survey, 2000.

U.S. Department of Agriculture. *USDA Agricultural Baseline Projections to 2010*. Office of the Chief Economist, Staff Report WABO-20001-1, Washington DC, February 2001.

U.S. Environmental Protection Agency (USEPA). *U.S. Department of Agriculture and U.S. Environmental Protection Agency Unified National Strategy for Animal Feeding Operations*. Office of Wastewater Management, EPA*,* March 9, 1999.

U.S. Environmental Protection Agency (USEPA). *National Pollutant Discharge Elimination System Permit Regulation and Effluent Limitation Guidelines and Standards for Concentrated Feeding Operations*. 40 CFR

Parts 9, 122 and 412.December 15, 2002.

U.S. Environmental protection Agency (USEPA). *NPDES Support document for the Final Concentrated Animal Feeding operation Rule*. Office of wastewater Management. December 2002.

U.S. Geological Survey (USGS). *The Quality of Our Nation's Waters: Nutrients and Pesticides*. USGS Circular 1225. U.S. Department of the Interior. 1999.

Table 1. Average Costs and Returns to Medium Dairy Farms (200 ≤ cows < 700) Spreading Lagoon –Liquid and Solid Manure on the Cropland in the Southwest region.

	Baseline	No Restriction	N-restriction	P-restriction
Animal units	620			
Acres owned	212			
Own acres planted	200	201	203	203
Acres received manure	146	68	181	187
Total planted acres	200	363	384	390
N-fertilizer purchased (lbs.)	13,035	35,344	9,602	13,125
P2O5-fertilizer purchased (lbs.)	3,999	13,652	4,226	2,653
K2O-fertilizer purchased (lbs.)	13,830	42,347	19,220	15,244
Fertilizer value of manure utilized by crops ($)	13,686	16,533	16,853	16,680
Net energy from home-grown crops (Mcal)	1,587,619	2,858,930	1,896,620	1,771,815
Crude protein from home-grown crops (lbs.)	178,414	319,548	210,831	197,001
Crude fiber from home-grown crops (lbs.)	602,11186	1,061,947	701,909	669,525
Dry matter (lbs.)	4,689,456	3,147,855	4,279348	4,466,232
Net energy purchased (Mcal)	2,068,736	797,426	1,759,735	1,884,541
Crude protein purchased (lbs.)	300,503	159,369	268,086	267,921
Crude fiber purchased (lbs.)	556,181	139,266	452,111	462,425
Fertilizer purchased costs ($)	6,988	19,336	7,156	6,529
Feed purchased costs ($)	144,910	56,751	123,557	131,631
Land leased cost ($)	0	19,550	5,418	3,471
Manure application costs ($)	26,402	27,790	28,800	29,310
Crop production costs [a]	38,748	67,258	45,454	44,984
Returns from milk sales ($)	732,754	732,7543	732,754	732,754
Returns from crop sales ($)	0	0	0	0
Net returns ($)	515,704	542,066	522,367	517,728

[a] Crop production costs excluding costs of commercial fertilizer costs and land lease and manure application.

Source: Results of individual whole-farm modeling.

Table 2. Average Costs and Returns to Large Dairy Farms (700 + cows) Spreading Lagoon -Liquid and solid Manure on the Cropland in the Southwest Region

	Baseline	No Restriction	N-restriction	P-restriction
Average animal units	1716			
Acres owned	563			
Own acres planted	415	385	387	387
Acres received manure	390	227	270	264
Total planted acres	415	385	453	457
N-fertilizer purchased (lbs.)	37,086	47,366	38,868	42,186
P2O5-fertilizer purchased (lbs.)	18,193	17,625	15,887	15,128
K2O-fertilizer purchased (lbs.)	63,400	61,802	60,723	59,388
Fertilizer value of manure utilized by crops ($)	20,164	17,794	23,354	22,328
Net energy from home-grown crops (Mcal)	3,789,402	3,801,708	4,074,539	4,056,796
Crude protein from home-grown crops (lbs.)	412,806	413,638	443,227	439,473
Crude fiber from home-grown crops (lbs.)	1,253,955	1,256,537	1,354,119	1,341,352
Dry matter (lbs.)	11,318,267	11,309,424	11,090,070	11,108,998
Net energy purchased (Mcal)	6,711,384	6,699,079	6,426,238	6,443,990
Crude protein purchased (lbs.)	1,017,539	1,016,703	987,114	990,868
Crude fiber purchased (lbs.)	1,955,504	1,952,921	1,855,340	1,868,106
Fertilizer purchased costs ($)	24,620	24,301	22,221	22,328
Feed purchased costs ($)	486,163	485,481	466,110	468,053
Land leased cost ($)	0	0	3,387	3,089
Manure application costs ($)	50,263	29,091	66,850	62,254
Crop production costs [a]	88,662	81,324	88,163	88,708
Returns from milk sales ($)	2,083,684	2,083,684	2,083,684	2,083,684
Returns from crop sales ($)	8,695	0	0	0
Net returns ($)	1,442,467	1,463,510	1,436,950	1439,249

[a] Crop production costs excluding costs of commercial fertilizer costs and land lease and manure application.

Source: Results of individual whole-farm modeling.

Table 3. Additional Leased Acres Needed by the Affected Dairy Farms in the Southwest region to Comply with Restriction on Land Application of Manure for Crop Production.

	N-restriction	P-restriction
Medium farms (200 ≤ cows < 700)		
	Acres (percent of surveyed farms in the group)	
Average	149 (38%)	153 (42%)
Maximum	936	993
Minimum	26	14
Lease costs	*Dollars*	
Average	14,269	8,291
Maximum	25,290	26,819
Minimum	716	395
Large farms (700 + cows)		
	Acres (percent of surveyed farms in the group)	
Average	205 (32%)	708 (10%)
Maximum	1,094	1,009
Minimum	33	581
Lease costs	*Dollars*	
Average	10,589	30,716
Maximum	99,521	83,304
Minimum	1,453	18,165

Table 4. Average Costs to Comply with Restrictions on Land Application of Manure from Crop Production

A. Compliance cost per farm

	N-restriction	P-restriction
Medium dairy farms Medium farms (200 ≤ cows < 700)	$/farm (percent of surveyed farms in group) [a]	
Average	(6,663) [b] (9%)	(2,024) [b] (19%)
Maximum	68,660	56,382
Minimum	(33,326)	(15,225)
Large dairy farms (700 + cows)		
Average	5,516(29%)	3,217 (9%)
Maximum	1,072,370	846,135
Minimum	(208,575)	(209,770)

B. Compliance cost per cwt of milk sold

	N-restriction	P-restriction
Medium dairy farms Medium farms (200 ≤ cows < 700)	$/cwt (percent of surveyed farms in group) [a]	
Average	(0.045) (9%)	(0.011) (19%)
Maximum	3.01	2.06
Minimum	(0.38)	(0.50)
Large dairy farms (700 + cows)		
Average	(0.04) (29%)	(0.03) (9%)
Maximum	1.33	1.30
Minimum	(1.65)	(1.34)

[a] Percent of farms in the group have positive compliance costs
[b] Number in the parenthesis is the income gain.

Source: Results of individual whole-farm modeling .

Table 5. Marginal Values of Manure (shadow prices) under Various Application Scenario

	Baseline	No-restriction	N-restriction	P-restriction
	$/1000 gallons (percent of surveyed farms in group) [a]			
Medium farms Medium farms (200 ≤ cows < 700)				
Average	(1.29) (100%)	(2.41) (100%)	(1.55) (60%)	(1.25) (44%)
Maximum	3.58	2.67	3.69	3.69
Minimum	0	0	(15.67)	(17.18)
Large dairy farms (700 + cows)				
Average	(1.82) (100%)	(1.53) (100%)	0.26 (81%)	0.15 (81%)
Maximum	0	0	82.51	71.33
Minimum	(4.03)	(2.85)	(4.03)	(4.02)

[a] Percent of farms in the group have positive or zero manure value.
Source: Results of individual farm modeling.

Table 6. Net Returns to Dairy Operation under Various Application Restriction Scenarios, dollars/cwt of milk sold

A. Value of production less operating costs (NETO)

	Baseline	**N-restriction**	**P-restriction**
Dollars/cwt (percent of surveyed farms in group) [a]			
Medium dairy farms (200 ≤ cows < 700)			
Average	2.60 (7%)	2.65 (7%)	2.62 (7%)
Maximum	9.75	9.66	9.19
Minimum	-3.69	-3.66	-3.63
Large dairy farms (700 + cows)			
Average	3.01 (0%)	3.05 (0%)	3.05 (0%)
Maximum	8.32	8.29	8.26
Minimum	1.41	1.41	1.41

B. Value of production less operating and overhead costs (NETF)

	Baseline	**N-restriction**	**P-restriction**
Dollars/cwt (percent of surveyed farms in group) [a]			
Medium dairy farms (200 ≤ cows < 700)			
Average	-2.84 (40%)	-2.79 (40%)	-2.82 (40%)
Maximum	5.95	5.87	5.41
Minimum	-9.93	-9.89	-9.87
Large dairy farms (700 + cows)			
Average	-0.22 (60%)	-0.19 (60%)	-0.18 (62%)
Maximum	6.70	6.23	6.23
Minimum	-1.70	-1.71	-1.71

[a] Percent of farms in the group has negative net return.