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Summary

This exploratory study shows estimated manure nutrient loadings on cropland for 78 selected feedlots in South Dakota to be 4.7 times greater than for 62 selected cow-calf operations. For 44% of feedlots studied, the estimated amounts of manure nitrogen (N) spread on cropland exceed the 75 lb/acre fertilizer N level recommended for corn with a 100 bu/A yield goal. For 40% of feedlots and 23% of cow-calf operations, amounts of manure N dropping on pasture exceed the 38 lb/A recommended fertilizer N level for pasture land. Since the design capacity of feedlots covered in the study is nearly 10 times the average for all feedlots in the state and the average size of herd for the cow-calf operators studied is 1.35 times the state average, the estimated percentages of beef cattle operations studied with potential nonpoint pollution from animal wastes are considerably greater than for beef cattle operations generally in the state.

Key Words: Manure Nutrient Loadings, Feedlots, Cow-Calf Operations, Nonpoint Source Pollution

Introduction

The National Research Council, in its recent study "Soil and Water Quality, An Agenda for Agriculture," reports that the concentration of cattle in large confinement feeding operations and the increasing regional concentration of dairy, poultry, and other animal production systems are giving rise to more manure being produced than can be used efficiently on nearby croplands. With concentrated livestock production, environmental concerns can arise in connection with (1) waste run-off from feedlots and (2) nutrients leaching into soil and water from manure in excess of the nutrients required by crops.

If management expertise is the same, possibilities for pollution are greater if cattle are fed in large feedlots. Point source pollution may increase because of the large amounts of feedlot waste available as potential run-off into surface water or leaching to groundwater in the immediate vicinity of large feedlots. Non-point source pollution may increase because the economic disincentives for transporting manure long distances from its point of origin may result in excessively heavy manure applications on farmland close to large feedlots.

In this study of livestock manure nutrient loadings on farmland for cattle feeding and cow-calf operations in South Dakota, two primary research questions are addressed:

1) Are nutrient loadings greater for feedlots or cow-calf operations? This question is significant since, on the one hand, cattle on feed are more geographically concentrated than cattle on pasture but, on the other hand, fed cattle account for only one-seventh as much as grazing cattle of the total estimated manure produced in the U.S.

2) Are nonpoint source pollution manure nutrient loadings in South Dakota environmentally dangerous? Some commentators believe that they are.

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Materials and Methods

Responses by 78 fed cattle and 62 cow-calf operators in South Dakota to questionnaires mailed during winter 1991-92 represent a main data source for this study. In each study, questionnaires were mailed by the South Dakota Agricultural Statistics Service to 500 randomly selected producers. Response rates were 42% and 26%; several respondents reported no longer producing cattle and/or backgrounding rather than finishing cattle for slaughter.

For simplicity, we assumed all spread manure to be solid raw. The amounts of solid raw manure assumed to be produced and available for land application by various species and types of livestock and poultry found on the surveyed farms are shown in Table 1. For information on the sources of these data, see Annex A of "Livestock Manure Production and Disposition: South Dakota Feedlots-Farms-Ranches," available from the author.

The total amounts of manure produced by various species and types of livestock and poultry on each of the 78 feedlot and 62 cow-calf operations were calculated by multiplying the data in Column 4 of Table 1 by the respective numbers of each type of livestock found in each farm operation. Percentages of these total amounts of manure assumed to drop directly on pasture land—versus to be scraped, collected, and spread on cropland—are shown in Table 2. The assumed elemental nitrogen (N), as percentages of raw solid manure applied to farmland at the time of land application, for various livestock species are as follows: poultry 1.74%, sheep .99%, beef cattle .72%, dairy cattle .49%, and hogs .42%.

Table 1. Amounts of manure produced by various species and types of livestock poultry assumed in the study

	Livestock management assumptions		Manure available for application	
Category of livestock	Body weight (lb)	Days in herd/flock	Lb/day	Tons for days in herd/flock
Beef cattle				
Brood cow	1,100	365	61	11.13
Service bull	1,700	365	94	17.16
Stockers	615	200	34	3.40
Finishing cattle	775	270	43	5.81
Dairy cow	1,300	365	93	16.97
Hogs				
Brood sow	350	365	11	2.01
Market hog	135	150	11	.83
Sheep				
Ewe	180	365	6.3	1.15
Market lamb	70	140	2.5	.18
Poultry				
Layer	7	365	.30	.055
Broiler	7	45	.40	.009

The percentages of manure dry matter, N, and losses were assumed to be the same for all beef producers in the study. Producers were assumed to follow sound management practices in their handling, storage, application, and incorporation of manure. Further, manure was assumed to be applied uniformly over all cropland receiving spread manure applications and to drop uniformly over all grazing land in the respective farming operations. We are aware that these assumptions are not entirely realistic. Without having detailed data to enable analytic attention to these issues, however, we decided to proceed with the study, and to openly acknowledge that the study results must be considered as indicative, not definitive.

Results and Discussion

Feedlots and Cow-calf Operations Studied

On average, the 78 feedlot managers operate 1,475 acres of cropland and 590 acres of pasture land. The cow-calf operations studied have only 44% as much cropland (650 acres) as the feedlot operations but 2.4 times as much pasture land (1,430 acres).

The mean design capacity of the feedlots studied is 890 head, which is nearly 10 times the state average feedlot size of 90 head. The average size of herd for the cow-calf operators is 116 head, which is 1.35 times the state average of 86.

Livestock Manure Nutrient Loadings

An estimated average of 5,370 tons of manure is produced annually by the livestock associated with each feedlot studied. The corresponding manure production for cow-calf operations is only 1,825 tons or 34% as much. Seventy-seven percent of the total manure produced on feedlots is spread on cropland, whereas only 46% of the total manure produced on cow-calf operations is spread on cropland.

Estimated annual applications of livestock manure per acre on cropland average 6.1 tons for feedlots and 1.3 tons for cow-calf operations. They range from 0.4 to 28 tons for feedlots and from 0.03 to 4.5 tons for cow-calf operations. Eight percent of feedlot operators spread more than 15 tons/A/yr.

The estimated average annual elemental nitrogen (N) application for feedlot operations is 98 lb/A (Table 3). For cow-calf operations, the average N application (21 lb/A) is only 21% as much. Nitrogen application rates for 44% of feedlots exceed 75 lb/A.

The estimated average annual amount of manure N dropping on pasture land of 33 lb/A for feedlots is significantly more ($P<.01$) than the average of 25 lb/A for cow-calf operations. The estimated amount of manure N dropping on pasture land exceeds 38 lb/A for 40% of feedlots and 23% of cow-calf operations.

Thus, although feedlots have 2.3 times as much cropland as cow-calf operations, their average cropland manure nutrient loading rates are 4.7 times as great as for cow-calf operations. Their average pasture land manure nutrient loading rates are 30-32% more than for cow-calf operations. With feedlots, manure nutrient loading rates are about 3 times as great on cropland as on pasture land. With cow-calf operations, on the other hand, manure nutrient loading rates on cropland are 15-17% less than those for pasture land.

These outcomes are associated with contrasts in (a) the average estimated total amount of manure produced by feedlot operations (5,370 tons) versus cow-calf operations (1,825 tons), (b) total manure spread on cropland as a ratio to that dropped on pasture land for feedlot operations (3.41) versus that for cow-calf operations (0.86), and (c) the cropland-pasture land mix for feedlot operations (2.5 times as much cropland as pasture land) versus cow-calf operations (only 46% as much cropland as pasture land).

Livestock Manure in South Dakota: A Nonpoint Source Environmental Hazard?

Identifying benchmarks against which the above estimated manure nutrient loadings can be evaluated is problem-prone. Maximum "environmentally safe" nutrient loadings on farmland depend—among many factors—on site-specific soil N levels, soil properties and

Table 2. Percentages of total manure produced assumed to drop directly on pasture land[a]

Category of livestock[b]	Feedlots	Cow-calf operations
Beef		
Service bulls	80	100
Brood cows	80	Actual
Stockers	80	80
Backgrounded cattle	n/a	80
Replacement heifers	n/a	60
Finishing cattle	Actual	0
Breeding ewes	80	80
Dairy cows	80	80

[a]The term "actual" reflects the numbers of days that producers reported cattle to graze on pasture land as percentages of 365 in the respective feedlot and cow-calf operations,.

[b]None of the manure produced by brood sows, market hogs, market lambs, layers, and broilers for either type of operation was assumed to drop on pasture land.

Table 3. Levels of elemental nitrogen (N) from livestock manure spread on cropland and dropped on pasture land, 78 feedlots and 62 cow-calf operations

Type of farmland and cattle operation	Estimated nutrient loading (lb N/acre/yr)	
	Range	Mean[a]
Cropland		
Feedlots	6-507	97.7
Cow-calf operations	1-65	20.9
Pasture land		
Feedlots	0-117	33.2
Cow-calf operations	3-91	25.2

[a]In each paired comparison, the mean nutrient loading for feedlots is significantly greater than for cow-calf operations ($P<.01$).

condition, aquifer depths, distance from surface water, crop nutrient requirements, and weather at the time of manure application. Nevertheless, we established general benchmarks for maximum recommended amounts of manure N for application to cropland and pasture land in S.D. as follows.

South Dakota State Law requires agricultural waste plans to be developed for new feedlots with a capacity for more than 1,000 head and for any existing feedlot which has been shown to be the source of water pollution. The waste utilization plan requires annual soil tests with subsequent manure application based on crop nitrogen requirements. The crop nitrogen requirement for corn, for example, is calculated as (1.45 * yield goal) - 20. The actual fertilizer recommendation is determined by subtracting the NO_3-N in a 2-ft soil sample from the nitrogen requirement.

The average corn yield in South Dakota is 80 bu/A. The fertilizer recommendation for a farmer with a 100 bu/A yield goal and a 50 lb/A NO_3-N soil test would be 75 lb/A. Nitrogen recommendations for grass are based on (25 * yield in tons) -soil NO_3-N to a 2-ft depth. If grass production is 3.5 tons/A, a typical fertilizer recommendation would be 38 lb/A.

Based on these manure N benchmarks, 44% of feedlots exceed the recommended 75 lb/A fertilizer N level for corn raised on cropland and 40% exceed the 38 lb/A recommended fertilizer N level for pasture land. Further, 23% of cow-calf operations exceed the 38 lb/A manure N benchmark level for pasture land. In interpreting these outcomes, however, it should be remembered that (1) the design capacity of the feedlots covered in the study is nearly 10 times the average for all feedlots in South Dakota and (2) the average size of herd for the cow-calf operators is 1.35 times the state average.

Conclusions

What conclusions can be drawn from the study? First, it would appear that the soil and water associated with substantial proportions of the South Dakota feedlots studied, and even for a minority of cow-calf operations studied, is potentially vulnerable to pollution from animal waste. We have determined through multiple regression analysis that the relationship between estimated manure nutrient loadings and feedlot size in this study is direct and statistically significant ($P<.01$). Further, the average design capacity for feedlots which have cropland manure N loadings exceeding 75 lb/A (1,332 head) is 2.4 times that of feedlots with cropland manure N loadings of less than 75 lb/A. Thus, animal waste from the vast majority of South Dakota feedlots of an average size or smaller is unlikely to pose a nonpoint source environmental hazard.

Second, findings from the study raise a question about the potential for soil and water pollution in states with cattle populations which are much more dense than those in South Dakota. For example, the average number of fed cattle marketed per feedlot in the nine major cattle feeding states in the Southern and Central Plains, Southwest, and Northwest ranges from 7 to 284 times that in South Dakota (see Table 2 of CATTLE 95-24).

In further exploring the issues raised in this research, we would encourage empirical research to (1) estimate amounts and nutrient content of manure produced in feedlots representing various conditions, (2) determine relationships among (a) manure production from feedlots of different sizes, (b) cropland areas required for environmentally safe distribution of that manure, and (c) distances that manure can economically be transported, and (3) explore alternative means for handling animal waste.