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# Farmland Manure Nutrient Loadings: South Dakota Feedlots and Cow-Calf Operations

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# FARMLAND MANURE NUTRIENT LOADINGS: SOUTH DAKOTA FEEDLOTS AND COW-CALF OPERATIONS

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## INTRODUCTION

The estimated annual value of the manure produced by livestock and poultry in the U.S. as fertilizer for farmland is around $2.5 billion. The corresponding value for manure produced in South Dakota is $172 million, which is about 5% of total cash receipts from marketings and government payments to farmers and ranchers in the state in 1992 (Taylor, 1994, p 32).

These estimated manure values represent the commercial market value of the elemental nitrogen (N), phosphorus (P), and potassium (K) contained in the manure produced by livestock, as a replacement for synthetic chemical fertilizers that otherwise would be purchased and applied to farmland. Whether these values are realized in practice depends on the quality of management practices followed in handling and disposing of manure. If such management practices are sound, the actual realized values of the manure produced in the U.S. and in South Dakota will approximate the values mentioned in the above paragraph.

To the extent that such practices are unsound, however, the actual realized value of manure becomes less. In the extreme, the value could become negative. The potential for negative values is accentuated for geographically concentrated livestock. With concentrated livestock production, environmental concerns can arise in connection with (1) waste run-off from feedlots ("point source pollution") and (2) nutrients leaching into soil and water from manure in excess of the nutrients required by crops and grasses ("non-point source pollution").[1]

Other things the same, possibilities for both types of pollution are greater if cattle are fed in large feedlots.[2] Point source pollution may increase because of the large amounts of feedlot waste available as potential run-off into ground and surface water sources 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 (Freeze and Sommerfeldt, 1985).

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[1]Also, if manure is spread on frozen ground, environmental problems can arise if manure nutrients run off with snow melt.

A possible hybrid "point-non-point pollution" situation can arise if manure accumulates around livestock watering locations and/or intermittent-use stock pens in grazing areas.

[2]One factor that may not be same is quality of livestock waste management. Twenty thousand cattle in one well designed and managed feedlot may give rise to fewer pollution problems than those same 20,000 cattle in 50 poorly designed and managed feedlots with 400 cattle each.

The results of a study of non-point source pollution for feedlot operations in South Dakota are reported in Taylor (1994).[3] In this report, similar results are reported for cow-calf operations in the state.[4] Special emphasis is given to comparing livestock manure nutrient loadings for cow-calf operations with those for feedlots. The comparison between cow-calf operations and feedlots is of particular interest because, 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 8% and grazing cattle account for as much as 55% of the total estimated manure produced in the U.S. (OTA, 1990, p 93).

## METHODOLOGY

With a few exceptions, the methodology in this study is the same as that followed in the previously noted study of feedlots (Taylor, 1994, pp 38-47). Differences are as follows.

In the feedlot study, we assumed standard weights of 1,100 lb and 1,700 lb for beef brood cows and service bulls, respectively. Since questions were included in the cow-calf questionnaire on producers' target weights for mature brood cows and service bulls, we took into account this body weight information in determining the amounts of manure produced per cow and bull for each cow-calf operator in this study.

In the feedlot study, we assumed that 80% of the manure produced by beef cows and bulls dropped directly on pasture land[5] and that 20% was scraped and spread on cropland. Since questions were included in the cow-calf study on numbers of days per year that cattle grazed on (a) pasture land and (b) crop residues, this information was taken into account in determining amounts of each producer's cow manure assumed to be applied to cropland versus pasture land. Also, 100% of bull manure was assumed to be dropped on pasture land in the cow-calf study.

In the feedlot study, feeders were asked to report the percent of total manure from their finishing cattle estimated to drop directly on grazing land. Only 0.5% of total finishing cattle manure was determined to drop on grazing land in that study. Since that percent was so small, we assumed in the cow-calf study that 100% of finishing cattle manure was scraped and spread

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[3]In reacting to a draft manuscript of this report, Charles H. Ullery, SDSU extension specialist in water and natural resources, indicated that the potential for problems with feedlots in South Dakota is considerably greater for point source than non-point source pollution.

"Feedlots" are defined by the South Dakota Agricultural Statistics Service as confined areas in which cattle intended for slaughter are fed (personal communication; February 28, 1995).

[4]The more general reports of managerial practices followed by the surveyed cow-calf operators and feedlot managers are found in Taylor and Feuz (1992 and 1994, respectively).

[5]In this report, "pasture land" should be interpreted to include rangeland.

on cropland. We also assumed a 270 day feeding period for finishing cattle and an average weight during the feeding period of 775 lb.

In the feedlot study, we did not ask about numbers of backgrounded calves. Since information on numbers of backgrounded calves was obtained in the cow-calf questionnaire, we took into account amounts of manure produced by backgrounded cattle in this study. The assumptions were as follows: a 91 day backgrounding period and an average weight during the backgrounding period of 520 lb. Further, we assumed that 80% of backgrounded cattle manure was dropped on pasture land.

In the feedlot study, we assumed that producers who had beef cow herds kept one service bull for every 25 cows in the herd. In calculating the herds' manure production, attention was given to both cows and bulls. Since a question was included in the cow-calf study on percent of brood cows artificially inseminated, this additional information was taken into account in estimating the number of service bulls in each producer's herd in this study.

Unlike in the feedlot study, information was obtained on heifer calf replacement rates in the cow-calf study. Therefore, we determined the number of heifer calves that each producer retained for replacement and estimated the amount of manure produced by them. Replacement heifers were assumed to weigh an average of 675 lb during the 442 day period of their being replacement heifers. Further, we assumed that 60% of their manure was dropped on pasture land.

In the feedlot study, all cattle feeders had cropland on which manure was assumed to have been spread. In the cow-calf study, five producers had no cropland. We assumed that all the manure produced for these five operations was applied to pasture land.

Percentages of manure dry matter, losses, N, and P were assumed to be the same for all beef producers in the study. Producers were assumed to follow sound management practices in the handling, storage, application, and incorporation of manure in their farming operations. 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 well 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.

## FEEDLOTS AND COW-CALF OPERATIONS STUDIED

Summary data on the nature of the feedlots and cow-calf operations studied are provided in Table 1. On average, the 78 feedlot managers operate 1,475 acres of cropland and 590 acres of pasture land. The 62 cow-calf operators studied have nearly identical total acreages, but they have only 44% as much cropland as the feedlot operators (650 acres) and 2.4 times as much pasture land (1,431 acres).

Table 1. Selected features of South Dakota feedlots and cow-calf operations studied.

| Feature | Feedlots | Cow-calf operations | Cow-calf operations as a ratio to feedlots |
|---|---|---|---|
| Number of producers | 78 | 62 | 0.79 |
| Mean acres cropland | 1,475 | 650 | 0.44 |
| Mean acres pasture land | 590 | 1,431 | 2.43 |
| Livestock enterprises[a] | | | |
| Beef cow herds | | | |
| Percent of producers | 58 | 100 | 1.72 |
| Mean number of cows | 135 | 116 | 0.86 |
| Finishing cattle | | | |
| Percent of producers | 100 | 16 | 0.16 |
| Mean design capacity (head) | 890 | 37 | 0.04 |
| Backgrounded cattle | | | |
| Percent of producers | n/a | 42 | n/a |
| Mean number sold per year | n/a | 73 | n/a |
| Stocker cattle | | | |
| Percent of producers | 10 | 16 | 1.60 |
| Mean number sold per year | 120 | 51 | 0.43 |
| Dairy cows | | | |
| Percent of producers | 12 | 5 | 0.42 |
| Mean number of cows | 90 | 19 | 0.21 |
| Brood sows | | | |
| Percent of producers | 14 | 19 | 1.36 |
| Mean number of sows | 75 | 37 | 0.49 |
| Slaughter hogs | | | |
| Percent of producers | 19 | 23 | 1.21 |
| Mean number sold per year | 750 | 356 | 0.47 |
| Breeding ewes | | | |
| Percent of producers | 4 | 8 | 2.00 |
| Mean number of ewes | 210 | 190 | 0.90 |
| Slaughter lambs | | | |
| Percent of producers | 4 | 2 | 0.50 |
| Mean number sold per year | 135 | 600 | 4.44 |
| Layers | | | |
| Percent of producers | 3 | 3 | 1.00 |
| Mean number of hens | 270 | 28 | 1.04 |
| Broilers | | | |
| Percent of producers | 3 | 2 | 0.67 |
| Mean number sold per year | 4,250 | 100 | 0.02 |

[a]The means shown below are for those producers who have the respective livestock enterprises.

The two main livestock enterprises found on the feedlot and cow-calf operations studied are beef cow herds and finishing cattle. The average size of herd for the cow-calf operators is 116 head, which is 1.45 times the state average of 80 cows per herd (USDC, 1989, p 29). The mean design capacity of the feedlots in the feedlot study is 890 head, which is nearly 12 times the state average feedlot size of 75 head (USDC, 1989, p 28). The 58% of feedlots that also have cow-calf operations have cow herds averaging 135 head each. Only 16% of the cow-calf operators studied finish cattle, with an average of 37 fat cattle marketed per year for each operator.

Forty-two percent of the cow-calf operators in this study background an average of 73 calves each. Other livestock enterprises are rather uncommon, with each involving between 2% and 23% of the producers studied and being relatively modest in size. The incidence of stocker cattle, brood sows, slaughter hogs, and breeding ewes is slightly greater for cow-calf operations than for feedlots, but the scale of these enterprises on the cow-calf operations tends to be smaller. Both the incidence and average size of dairy herd associated with feedlots, however, are greater than with cow-calf operations.

An estimated average of 5,370 tons of manure is produced annually by the livestock associated with each feedlot studied (Table 2). 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 by cow-calf operators is spread on cropland.

Table 2. Disposition and sources of manure produced: 78 feedlots and 62 cow-calf operations.

| Disposition and sources of manure | Feedlots | Cow-calf operations |
|---|---|---|
| Mean amount of manure produced annually per producer (tons) | | |
| Spread on cropland | 4,150 | 845 |
| Dropped on pasture | 1,220 | 980 |
| Total | 5,370 | 1,825 |
| Percentage of total manure produced, by category of livestock | | |
| Finishing cattle, including stockers | 92.2 | 6.1 |
| Beef cow-calf herd, including bull | 3.4 | 87.4 |
| Hogs | 2.6 | 4.5 |
| Dairy cows | 1.7 | 0.9 |
| Sheep and poultry | 0.1 | 1.1 |
| | 100.0 | 100.0 |

Of the total manure produced in feedlot operations, finishing cattle account for 92%, and beef cows and hogs for 3% each. Of the total manure produced in cow-calf operations, beef cow herds account for 87%, finishing cattle for 6%, and hogs for 5%.

Estimated annual applications of livestock manure per acre of cropland average 6.1 tons for feedlots and 1.3 tons for cow-calf operations (Table 3). They range from 0.4 to 28 tons for feedlots and from 0.03 to 4.5 tons for cow-calf operations. For 8% of feedlot operations, spread manure application rates on cropland are 15 tons/acre or more.

Table 3. Tons of livestock manure spread per acre of cropland: 78 feedlots versus 62 cow-calf operations.

| Application rate (ton/acre/year) | Feedlots | Cow-calf operations |
|---|---|---|
| Range | 0.4 - 28.1 | 0.03 - 4.48 |
| Mean | 6.1 | 1.3 |
| Percentages of producers with following application rates | | |
| Less than 1.00 | 10.3 | 48.2 |
| 1.00 - 1.99 | 20.5 | 28.6 |
| 2.00 - 3.99 | 15.4 | 21.4 |
| 4.00 - 5.99 | 16.7 | 1.8 |
| 6.00 - 9.99 | 17.9 | 0 |
| 10.00 - 14.99 | 11.5 | 0 |
| 15.00 or more | 7.7 | 0 |
| | 100.0 | 100.0 |

## LIVESTOCK MANURE NUTRIENT LOADINGS

This section on livestock manure nutrient loadings is comprised of two parts. The first concerns feedlot and cow-calf operations from throughout all of South Dakota. The second concerns a separate analysis for cow-calf operators located in eastern versus western South Dakota.

### Feedlot and cow-calf operations throughout South Dakota

The estimated amounts of elemental nitrogen (N) and phosphorus (P) in the livestock manure spread on **cropland** for the feedlots and cow-calf operations studied are shown in Tables 4 and 5. For cow-calf operations, an average of 21 lb/acre of N is found in the livestock manure applied to cropland. This is 21% as much as the average for feedlots (98 lb/acre). Nitrogen application rates exceed 150 lb/acre for 21% of feedlots, 250 lb/acre for 8% of feedlots, and 400 lb/acre for 4% of feedlots. The maximum N nutrient loading from manure for cow-calf operations is 65 lb/acre, which is only 13% as much as for feedlots (507 lb/acre). For cow-calf operations, an average of 6.6 lb/acre and a maximum of 20 lb/acre of phosphorus are found in the livestock manure applied to cropland.

Table 4. Levels of nitrogen in livestock manure spread on cropland: 78 feedlots versus 62 cow-calf operations.

| Nutrient loading rate (lb/acre/year) | Feedlots | Cow-calf operations |
|---|---|---|
| Range | 6 - 507 | 1 - 65 |
| Mean | 97.7[a] | 20.9[a] |
| Percentages of producers with following nutrient loading rates | | |
| Less than 10.0 | 9.0 | 32.1 |
| 10.0 - 19.9 | 9.0 | 28.6 |
| 20.0 - 34.9 | 11.5 | 21.4 |
| 35.0 - 64.9 | 24.3 | 17.9 |
| 65.0 - 99.9 | 12.8 | 0 |
| 100.0 - 139.9 | 9.0 | 0 |
| 140.0 - 224.9 | 14.1 | 0 |
| 225 or more | 10.3 | 0 |
| | 100.0 | 100.0 |

[a]These means significantly differ from each other at the 0.01 level.

Table 5. Levels of phosphorus in livestock manure spread on cropland: 78 feedlots versus 62 cow-calf operations.

| Nutrient loading rate (lb/acre/year) | Feedlots | Cow-calf operations |
|---|---|---|
| Range | 2 - 159 | 0.4 - 20 |
| Mean | 30.5[a] | 6.6[a] |
| Percentages of producers with following nutrient loading rates | | |
| Less than 4.0 | 10.3 | 39.3 |
| 4.0 - 5.9 | 5.1 | 21.4 |
| 6.0 - 9.9 | 12.8 | 16.1 |
| 10.0 - 19.9 | 25.6 | 21.4 |
| 20.0 - 29.9 | 12.8 | 1.8 |
| 30.0 - 44.9 | 10.3 | 0 |
| 45.0 - 64.9 | 12.8 | 0 |
| 65.0 or more | 10.3 | 0 |
| | 100.0 | 100.0 |

[a]These means significantly differ from each other at the 0.01 level.

The estimated amounts of elemental nitrogen (N) and phosphorus (P) in the livestock manure that drops on **pasture land** for the feedlots and cow-calf operations studied are shown in Tables 6 and 7. For cow-calf operations, an average of 25 lb/acre of N is found in the livestock manure that drops on pasture land; this is 76% as much as the average for feedlots (33 lb/acre). For cow-calf operations, an average of 7.8 lb/acre and a maximum of 29 lb/acre of phosphorus are found in the livestock manure that drops on pasture land.

Table 6. Levels of nitrogen in livestock manure dropped on pasture land: 78 feedlots versus 62 cow-calf operations.

| Nutrient loading rate (lb/acre/year) | Feedlots | Cow-calf operations |
|---|---|---|
| Range | 0 - 117 | 3 - 91 |
| Mean | 33.2[a] | 25.2[a] |
| Percentages of producers with following nutrient loading rates | | |
| Zero | 31.8 | 0 |
| 0.1 - 19.9 | 9.5 | 48.4 |
| 20.0 - 39.9 | 22.2 | 32.2 |
| 40.0 - 59.9 | 15.9 | 13.0 |
| 60.0 - 79.9 | 11.1 | 3.0 |
| 80 or more | 9.4 | 3.0 |
| | 100.0 | 100.0 |

[a]These means significantly differ from each other at the 0.01 level.

Table 7. Levels of phosphorus in livestock manure dropped on pasture land: 78 feedlots versus 62 cow-calf operations.

| Nutrient loading rate (lb/acre/year) | Feedlots | Cow-calf operations |
|---|---|---|
| Range | 0 - 36 | 1 - 29 |
| Mean | 10.1[a] | 7.8[a] |
| Percentages of producers with following nutrient loading rates | | |
| Zero | 31.8 | 0 |
| 0.1 - 4.9 | 6.3 | 37.1 |
| 5.0 - 9.9 | 15.9 | 35.5 |
| 10.0 - 14.9 | 15.9 | 16.1 |
| 15.0 - 19.9 | 12.7 | 6.5 |
| 20.0 - 24.9 | 9.5 | 1.6 |
| 25 or more | 7.9 | 3.2 |
| | 100.0 | 100.0 |

[a]These means significantly differ from each other at the 0.01 level.

Thus, although feedlots have 2.3 times as much cropland as cow-calf operations, their average cropland manure nutrient loading rates are 4.6-4.7 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 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 (2.50) versus that 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 45% as much cropland as pasture land).

**Cow-calf operations: eastern versus western South Dakota**

Twenty-two of the 62 cow-calf operations studied are located west of the Missouri River and the remaining 40 are east of the river (Table 8). Operations in the west are larger than those in the east, by the following multiples:

* 2.2 times the size of beef cow herd;
* 1.5 times the cropland acreage; and
* 6.9 times the pasture land acreage.

For both cropland and pasture land, manure N and P loading rates are greater for cow-calf operations in the east than in the west. The rates are nearly 50% greater for cropland and more than twice as great for pasture land. One factor underlying this outcome is a pasture stocking rate in the east that is more than 3 times as great as that in the west.

Table 8. Selected features of cow-calf operations studied, by location in state.

| Feature | East | West | State |
|---|---|---|---|
| Number of producers | 40 | 22 | 62 |
| Mean acres cropland | 567 | 826 | 650 |
| Mean acres pasture land | 463 | 3,191 | 1,431 |
| Size of herd (head cows) | 81 | 178 | 116 |
| Pasture stocking rate (cows per 100 acres pasture land) | 17.5 | 5.6 | 8.1 |
| Nutrient loading intensities (lb/acre/year) | | | |
| Cropland | | | |
| Nitrogen | 23.3 | 15.8 | 20.9 |
| Phosphorus | 7.3 | 4.9 | 6.6 |
| Pasture land | | | |
| Nitrogen | 31.1 | 14.4 | 25.2 |
| Phosphorus | 9.6 | 4.5 | 7.8 |

## INTERPRETATION OF FINDINGS

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 location-specific soil N and P levels, soil properties and condition, aquifer depths, crop nutrient requirements, and weather at the time of manure application.

Nevertheless, information on "threshold levels" of manure application is provided in three literature sources. Further, three states in the Midwest and Central Plains have guidelines for maximum recommended levels of manure N.

### Threshold levels of manure application

Manges et al. (1971) report salt-related yield reductions in the Great Plains for corn forage when beef cattle dry manure application rates exceeded 100 tons/acre. Based on a 14-year study of beef feedlot manure utilization, Mathers and Stewart (1984, p 1025) concluded that "manure applications of 67 Mg/ha (29.9 tons/acre) or more may cause salt or high ammonia damage to emerging seedlings and N losses by nitrate leaching below the root zone." Young et al. (1985, p 443) indicate that manure applications in excess of 40 tons/acre, which are common on dairy farms in southeastern Pennsylvania, result in excess nitrogen percolating through the root zone.

### State guidelines on maximum recommended levels of manure N

In response to growing environmental concerns over possible sources of soil and water pollution, many states are in the process of formulating/revising guidelines and regulations concerning land application of livestock manure. In a recent review of animal waste control programs in IA, IL, KS, MN, MO, NE, NC, SD, and WI, Agena (1994, p 1) determined that (1) all nine states have active animal waste control programs; (2) six of the nine states require certain confinement feeding operations to submit plans and obtain state approval prior to construction of new or expanded production facilities; and (3) one state **regulates** animal waste control, seven states **recommend** waste application be limited to rates that meet the agronomic nitrogen needs of the crops grown,[6] one **recommends** disposal be based on both nitrogen and phosphorus considerations, and one **recommends** disposal rates be based on hydrologic considerations.

Information on specific **guidelines** for land application of animal wastes in three states follows. At present, Kansas has a recommended nutrient guideline of a maximum of 250 lb/acre of nitrogen. However, the Kansas Bureau of Water is in the process of introducing into permits for land application of manure a maximum allowable amount of 100 lb/acre of nitrogen; applicants who desire to apply larger amounts must present plans showing that, under their

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[6]See Annex A for current nitrogen recommendations for crops in South Dakota.

circumstances, soil/water quality would not be impaired by their proposed higher nutrient loading (personal communication, Walter Morgan, Division of Environment, Kansas Bureau of Water, Topeka, February 16, 1995).

The Indiana Department of Environmental Management provides the following best management practice guidelines for the land application of livestock manure (IDEM, 1993, p 7):

> Based on application rates of 150 pounds of available N/acre/year, a minimum number of acres must be provided (for disposal of manure)... Depending on the type of crop grown and soil fertility, acreage may vary for the proper utilization of nitrogen.

Excerpts from Iowa's "guidelines" on land application of animal wastes are as follows (IDNR, 1994, p 10-11):

> To minimize the potential for nitrate leaching to groundwater, nitrogen application from all sources, including animal wastes, legumes, and commercial fertilizers, should not exceed the annual nitrogen requirement of the crop being grown... The maximum **total nitrogen** application in any one year should not exceed 400 pounds per acre. The average nitrogen application rate over an extended period should not exceed 250 pounds per acre of **available nitrogen** per year. (These rates) should only be used with high nitrogen use crops...

**Assessment of South Dakota manure loadings on farmland**

The average cropland manure applications of 6.1 tons/acre for the feedlot operations and 1.3 tons/acre for the cow-calf operations in the South Dakota study are far less than any "danger-level" represented in the three threshold level manure application studies. Even the maximum application of 28 tons/acre for one feedlot falls short of all three threshold levels.

None of the South Dakota cow-calf operations studied were to determined to have manure N levels on either cropland or pasture land that exceed the current maximum manure N guideline levels for IA, IN, or KS. The same is true for pasture land associated with cattle feeding operations. For cropland associated with feedlot operations, however, minorities of South Dakota feedlot operators have estimated manure N levels that exceed the recommended maximum manure N levels in the three referenced states:

* 150 lb/acre of N: 21% of producers;
* 250 lb/acre of N: 8% of producers; and
* 400 lb/acre of N: 4% of producers.

Based on these rather "soft" benchmarks and acknowledging that some of the assumptions underlying analysis of data in this study are not fully met in the real world, it would appear that the intensity of manure applications for the vast majority of the South Dakota feedlot and cow-calf operations covered in this study is not likely to be in an environmental danger-zone. This finding is particularly significant in view of (1) the design capacity of the feedlots covered in the study being 12 times the average for all feedlots in South Dakota and (2) the average size of herd for the cow-calf operators being 1.45 times the state average. One critical explanation for the study's findings is undoubtedly the much lesser concentration of cattle in South Dakota--compared to the nation's major cattle feedings states in the Central and Southern Plains, Southwest, and Northwest (Taylor, 1995).

## REFERENCES CITED

Freeze, B.S. and T.G. Sommerfeldt. 1985. Breakeven hauling distances for beef feedlot manure in Southern Alberta. **Can J Soil Sc** 65:687-693.

Manges, H.L., L.A. Schmid, and L.S. Murphy. 1981. Beef feedlot manure and soil water movement. Land disposal of cattle feedlot wastes. IN Livestock waste management and pollution abatement. St. Joseph, MI: Amer Soc Agric Engineering.

Mathers, A.C. and B.A. Stewart. 1984. Manure effects on crop yields and soil properties. **Trans of ASAE-1984**. pp 1022-26.

OTA. 1990. Technologies to improve nutrient and pest management. IN Beneath the bottom line: Agricultural approaches to reduce agrichemical contamination of groundwater. Rpt OTA-F-418. Office of Technology Assessment, U.S. Congress. Washington, D.C.: U.S. Government Printing Off. Nov.

Taylor, D.C. 1995. Changes in concentration of the U.S. fed cattle industry: 1973-1993. Manuscript submitted to **Feedstuffs**. Jan 25.

Taylor, D.C. 1994. Livestock manure production and disposition: South Dakota feedlots-farms-ranches. Econ Res Rpt 94-4. Brookings: Econ Dept, So Dak State Univ, Dec. 70 pp.

Taylor, D.C. and D.M. Feuz. 1994. Cattle feedlot management in South Dakota. Econ Res Rpt 94-1. Brookings: Econ Dept, So Dakota State Univ. Mar. 42 pp.

Taylor, D.C. and D.M. Feuz. 1992. South Dakota beef cow-calf producer management practices. Econ Res Rpt 92-7. Brookings: Econ Dept, So Dakota State Univ. Dec. 57 pp.

USDC. 1989. 1987 Census of agriculture; Vol 1, Geographic area series; Part 41, South Dakota and county data. Washington, D.C.: Bureau of the Census, U.S. Dept of Commerce.

# ANNEX A

## NITROGEN FERTILIZER RECOMMENDATIONS FOR SOUTH DAKOTA CROPS[1]

Nitrogen fertilizer recommendations are made by subtracting the $NO_3$-N soil test value in the top two feet of soil from the calculated nitrogen requirement for a given yield goal. The nitrogen requirement for crops grown in South Dakota is listed in Table 1.

Table 1. Nitrogen Recommendations Using 2-ft. $NO_3$-N Test. 1/

| Crop | Unit | Nitrogen Required lbs |
|---|---|---|
| Wheat | bu | 2.4 x yield |
| Oats | bu | 1.3 x yield |
| Barley | bu | 1.5 x yield |
| Rye | bu | 2.4 x yield |
| Flax | bu | 3.0 x yield |
| Corn (Grain) | bu | (1.45 x yield)-20 |
| Corn (Silage) | ton | (11.6 x yield)-20 |
| Sorghum (Grain) | bu | 1.1 x yield |
| Sorghum, Sudan (hay) | ton | 25 x yield |
| Grass (hay) | ton | 25 x yield |
| Sunflowers | cwt | 5.0 x yield |
| Edible beans | cwt | (7.5 x yield)-75 |
| Millet | cwt | 4.0 x yield |
| Rape | cwt | 6.0 x yield |
| Mustard | cwt | 6.0 x yield |
| Safflower | cwt | 5.0 x yield |
| Buckwheat | bu | (2.73 x yield)-16 |
| Potatoes | cwt | (.5 x yield)-20 |

1/ Fertilizer nitrogen to apply is equal to the nitrogen requirement minus soil $NO_3$-N to a 2-ft depth.

Example 1: The farmer has a 40 bushel wheat yield goal and his $NO_3$-N soil test level of 45 lbs/A.
40 bu x 2.4 lbs N/Bu = 96 lbs N requirement.
96 - 45 lbs soil test $NO_3$-N = 51 lbs N fertilizer needed.

Example 2: The farmer has a 100 bushel corn yield goal and his $NO_3$-N soil test level of 45 lbs/A.
(100 bu x 1.45 lbs N/Bu)-20 lbs = 125 lb N requirement.
125 - 45 lbs soil test N = 80 lbs N fertilizer needed.

Without a two-foot $NO_3$-N test, an assumption fo 40 lb/acre residual $NO_3$-N is made. Therefore, Recommended N = Required Nitrogen (Table 1) - 40. If the previous crop was black fallow, use 75 instead of 40 as the estimated residual 2-ft. $NO_3$-N level.

[1] Excerpted from J. Gerwing, R. Gelderman, and P. Fixen. 1988. Fertilizer recommendations guide. EC750. Brookings: So Dakota State Univ Coop Ext Serv, p 22.