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NITROGEN MANAGEMENT IN SOUTHEASTERN MINNESOTA

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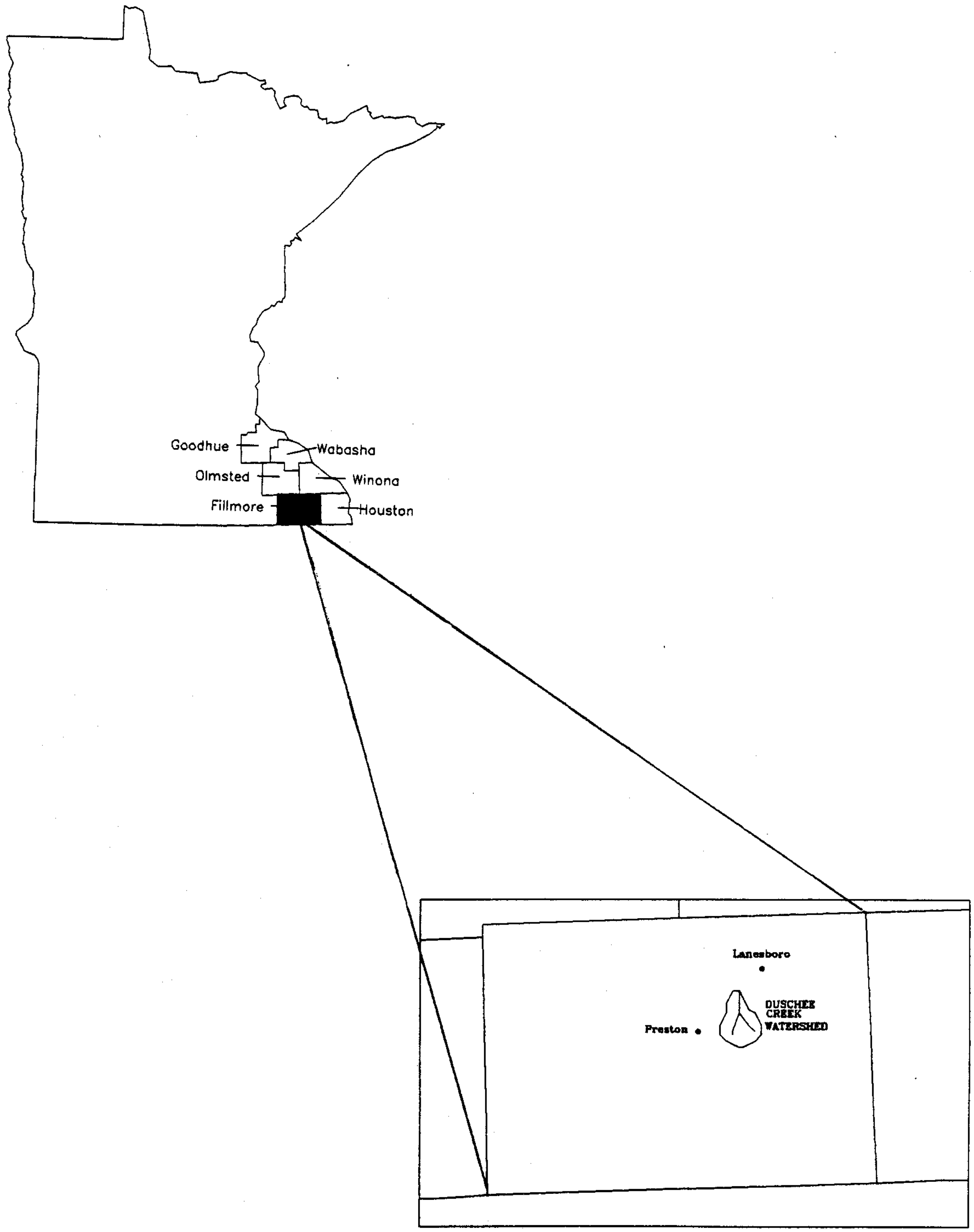

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NITROGEN MANAGEMENT IN SOUTHEASTERN MINNESOTA

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The six county region of Southeastern Minnesota (SE MN) is an area characterized by relatively intensive agricultural cropping practices and significant levels of livestock production (figure 1). The karst formations which underlie much of this area lead to relatively rapid transport of nitrates and other mobile chemicals into shallow aquifers. While nitrates are commonly found in water supplies in low concentrations (1-3 ppm NO_3-N), higher levels are now found in a large proportion of the wells that were tested in this area. A study of the Duschee Creek watershed[2] (watershed) in central Fillmore County, an area representative of much of the region, found that 63% of the 52 wells tested had nitrate (NO_3-N) levels in excess of 3 ppm and 21% had levels that exceed the current 10 ppm maximum contaminant level for public drinking water (Alexander and Wheeler).

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[2]Data for the watershed was compiled by the University of Minnesota Center for Urban and Regional Affairs in a 1986 survey of farmers in the watershed. Results for participating farmers were extrapolated to the entire watershed. Components, by weight and type, of each available livestock data category were estimated.

Such findings combined with current nitrogen fertilizer application levels have led to increased public attention and concern related to the quality of ground water supplies. High NO_3-N levels in drinking water are known to increase the risk of methemoglobinemia or "blue baby" syndrome in infants (Keeney, 1983) and are suspected of increasing cancer risk (Weisenburger, 1985). Their research indicates that elevated nitrate levels are resulting in high known plus potentially much higher unknown costs for ground water users. At least one county, Olmsted County, in the area requires new wells for domestic use not to have NO_3-N levels in excess of 3 ppm.

Agricultural sources of elevated ground water nitrate levels include commercial fertilizers, animal wastes, and biologically fixed N from legumes. Research on the relationships between agricultural production practices and nitrate levels found in water supplies is in the early stages, so no definitive estimates of the effects of particular agricultural practices on ground water quality are available. Consequently, it is too early to identify the changes in agricultural practices necessary to meet specific water quality goals. However, there is general agreement that reducing nitrogen application rates in current production systems or altering application practices so that a greater proportion of the nitrogen applied can be used by the crop will lead to reduced nitrate concentrations in ground water.

This paper considers the various sources of nitrogen available for crop production and develops a series of nitrogen budgets for farm, watershed, county, and region. Based on aggregate estimates of nitrogen requirements for crop growth and nitrogen availability from legumes, animal wastes, and commercial fertilizers, average total available nitrogen levels substantially exceed crop requirements. Estimates of nitrogen sources and uses on individual farms indicates that farms with livestock operations, particularly dairy farms, contribute disproportionately to the aggregate average excesses. Furthermore, if more nitrogen conserving methods of handling manure were used, the need for nitrogen fertilizers would be significantly reduced. However, efficient use of nitrogen from animal wastes may not be compatible with economic efficiency from the farmer's perspective, because the value of the nutrients gained may be less than the additional costs associated with more efficient collection and application systems.

The nitrogen budget model is described in section II, followed by the results in section III. The economic and policy implications of the results are presented in section IV and V. Finally, some additional questions are posed in the summary section VI.

THE NITROGEN BUDGET MODEL

Our model provides a method of estimating the nitrogen needed for the current levels of corn production and the available sources of that nitrogen. Corn is the only significant crop in southeastern Minnesota which is profitably fertilized with nitrogen (at least 95% of the nitrogen fertilizer used in the area is applied to corn). A relatively insignificant number of acres is planted to other crops, such as wheat and sweet corn, which are fertilized with nitrogen. Legumes are not typically fertilized with nitrogen fertilizers. Thus, estimating the nitrogen balance for corn provides a basis for considering the initial impact of a policy aimed at reducing nitrogen inputs.

Two versions of the model were developed. One is designed to estimate the per acre nitrogen balance for an aggregation of farms and is similar to the work of Duffy (1987). This version was used in the regional, county and watershed applications. The other, designed for application at the farm level, allows consideration of the effects of particular practices on nitrogen availability. For example, the farm level model considers the impact of fertilizer application methods, residue levels, and timing on the proportion of fertilizer that is actually available to the crop. In contrast, the aggregate model considers all nitrogen applied to be available.

A description of our estimation of needs and sources follows. Differences between the aggregate and farm level versions of the model are noted where significant.

NITROGEN NEEDS

Needs are defined as the estimated amount of nitrogen required to obtain the average corn yield or yield goal[3] following two or more years of corn. Needs per bushel are estimated at 1.1 pounds of nitrogen, which is the average of a rule of thumb for the corn belt (1.2) and the approximate applications recommended by the University of Minnesota Soil Testing Laboratory (1.0). The effects on the results of using 1.0 and 1.2 pounds of nitrogen per bushel are shown parenthetically.

Yield responses to nitrogen is, in fact, non-linear, with marginal response to added nitrogen decreasing as the level of total nitrogen increases. Our linear response is adequate for estimating total nitrogen required to grow current average yields or meet yield goals. However, this

[3] Average yields for SE and Fillmore County are 1985 averages from Minnesota Agricultural Statistics. No data regarding average yield for the watershed is available, so the Fillmore County average was used. The farmers' stated 1987 goals were used in the individual farm application.

would not be adequate to determine the economic optimum level of nitrogen application or necessarily provide a reasonable estimate of crop needs when yields are outside of the range considered.

SOURCES

Sources of nitrogen include commercial fertilizer, biologically fixed N from previous legume crops in rotation (soybeans and alfalfa), and animal manure. Nitrogen sources are estimates of the amount of nitrogen available to be used on corn, not necessarily the amount applied. For example, some manure is spread on pasture.

As a proxy measure of nitrogen applied to corn acres for all three levels of aggregation, we used 95% of dealer sales of nitrogen fertilizer in Southeastern Minnesota for the 1985-6 crop year. We estimated that 5% of the nitrogen was applied to crops other than corn. No application data by county or region are available. Use does not coincide geographically with purchase, as was apparent from dramatic variations in individual county data. Using the SE Minnesota six county average for the Fillmore County and Watershed applications reduces the proportional impact of interregional sales, but obscures differences in use patterns that might exist within Southeastern Minnesota.

Individual farm commercial fertilizer use is actual nitrogen applied adjusted to reflect estimated losses due to timing and method of application. In practice, these adjustments were minimal, because all four farmers incorporated or injected fertilizer just prior to or at planting time or sidedressed and application losses were estimated to be minimal.

Estimated nitrogen credits from legume crops are estimates provided by the University of Minnesota Soil Testing Laboratory (Rehm, et al, 1985). The Laboratory recommends reducing nitrogen applications by 30 pounds per acre on corn after soybeans as compared to continuous corn. The application reduction following alfalfa depends on the quality of the alfalfa plowed under. We conservatively assumed that all stands rotated were of poor quality, indicating a one year application reduction of 60 pounds per acre of alfalfa rotated to corn. A reduction of 100 pounds of nitrogen the first year, 60 pounds the second year, is recommended if the rotated alfalfa stand is of good quality. We assumed all soybean acres and 1/3 of the acres in alfalfa are rotated to corn in the subsequent year. The 60 pound one year credit for alfalfa was also used in the farm level applications based on discussions with farmers.

Southeastern Minnesota is characterized by intense livestock production, including poultry, dairy, beef, and hog operations. Available nitrogen from livestock was estimated as follows:

1. Livestock data for Southeastern Minnesota and Fillmore County were obtained from Minnesota Agricultural Statistics - 1986. Watershed livestock data were obtained from the University of Minnesota Center for Urban and Regional Affairs' 1986 survey of farmers. Nitrogen production was estimated using per animal annual production estimates, again by weight and type, obtained from the Livestock Waste Facilities Handbook.
2. Nitrogen collected in manure handling systems is based on the estimated proportion of time each type of animal is customarily not on pasture.
3. Nitrogen handling, storage, and application losses were based upon estimates of actual manure handling practices. Proportional losses,

given particular practices, were obtained from the Livestock Waste Facilities Handbook.

4. Nitrogen contained in manure is generally released and becomes available over three years. We assumed that total nitrogen available to corn from current and prior year manure applications was equal to total nitrogen in the current year's application. This implicitly assumes constant livestock intensity over time.

For the farm level model, practices were those reported by the farmers. Nitrogen production and proportional losses, for given practices, were determined as in the aggregate case.

Fertilizer sales and livestock data by county are not available for years prior to 1985, so it was not possible to construct a series of aggregate budgets to compare use among years.

RESULTS

Both the aggregate and individual farm results summarized in Tables 1-3 (Tables 1 to 3 in Appendix A provide more detailed results) indicate that fertilizer and legume credits roughly meet the nitrogen requirements of the corn crop. Excesses in each case are approximately equal to the nitrogen in applied manure.

AGGREGATE

The aggregate budget excesses for Fillmore County and Southeastern Minnesota are about equal at approximately 55 pounds of N per acre. The watershed excess, 111 lbs. per acre, reflects a much higher concentration of livestock than is typical of the County or Southeastern Minnesota. The nitrogen needs assumptions of 1.0 or 1.2 pounds per bushel would result in

TABLE 1
AGGREGATE NITROGEN(N) BUDGETS
SOUTHEASTERN MINNESOTA, FILLMORE COUNTY, AND DUSCHEE CREEK WATERSHED

	SE MN	County	Watershed[5]
	Pounds N/acre		
N needed to grow avg. yield[1]	127	118	118
Sources:			
Commercial fertilizer[2]	112	112	112
Soybean credits[3]	7	7	2
Alfalfa credits[4]	9	6	10
Manure (Tables 4-6)	61	47	105
Total Sources	190	172	229
Excess per Acre	63	54	111

NOTES

1 1.1 lbs. of N per bushel. Average yield is 1985 yield as reported in Minnesota Agricultural Statistics.

2 95% of 1985-86 crop year sales in the six county area, divided by corn acres planted.

3 30 lbs. of N from each acre of soybeans harvested the previous year divided by corn acres planted.

4 60 lbs. of N per acre of alfalfa rotated to corn divided by corn acres planted. Alfalfa acres rotated are estimated at 1/3 of total acres in alfalfa.

5 Watershed data was obtained through a survey performed by the University of Minnesota Center for Urban and Regional Affairs during 1986. Surveys were sent to all farmers in the watershed. Actual responses accounted for 76% of the farmers. Results were extrapolated to the entire watershed. No fertilizer use or yield data were obtained so county level data were used.

TABLE 2
INDIVIDUAL FARM NITROGEN(N) BUDGET
ACTUAL CURRENT PRACTICES

	Farm			
	A	B	C	D
	lbs. N/acre			
N needed to meet yield goal[1]	164	154	164	151
Sources:				
Commercial fertilizer[2]	155	130	145	138
Soybean credits[3]	26	--	--	--
Alfalfa credits[3]	10	27	17	--
Manure (Tables 7 to 9)	33	130	29	--
Total Sources	224	287	191	138
Excess per Acre	60	133	27	-13

NOTES

1 1.1 lbs. of N per bushel.
2 Actual average applications adjusted for estimated losses due to handling practices.
3 30 lbs. of N per acre planted to soybeans the previous year divided by corn acres.
4 60 lbs. of N per alfalfa acre actually rotated to corn divided by corn acres.

TABLE 3
INDIVIDUAL FARM NITROGEN(N) BUDGET
"IMPROVED" PRACTICES OF HANDLING COLLECTED MANURE AND FERTILIZER

	FARM			
	A	B	C	D
	lbs. N/acre			
N is needed to meet yield goal[1]	164	154	164	151
Sources:				
Commercial Fertilizer[2]	155	133	152	151
Soybean Credits[3]	26	--	--	--
Alfalfa Credits[4]	10	27	17	--
Manure Tables (Tables 7 to 9)	56	173	64	--
Total Sources	247	333	233	151
Excess Per Acre	83	179	69	--

NOTES

1 1.1 lbs. of N per bushel.

2 Actual average applications. Assumes practices estimated to approximately minimize leaching and denitrification losses. Specifically, assumes all N is applied in the spring and injected or incorporated on a field with low or medium residue levels.

3 30 lbs. of N per acre planted to soybeans the previous year, divided by corn acres.

4 60 lbs. of N per alfalfa acre actually rotated to corn divided by corn acres.

estimated excesses of about 10 pounds higher or lower. Care should be taken in comparing the Watershed results with the county and the regional results, due to lack of yield and fertilizer application data and lack of detailed livestock data for the Watershed.

Tables 4-6 present estimated production and losses of nitrogen from livestock waste for each of the areas of aggregation. The magnitude of available nitrogen is highly dependent upon the estimates of storage, handling, and application practices which determine the losses. However, since available nitrogen from manure is roughly equal to estimated excess nitrogen, any errors in our estimates would not change nitrogen excesses to deficits.

FARM LEVEL

Actual Practices

The farm level results indicate that the nitrogen balance is highly dependent upon the type of operation. Farms A and C are primarily beef operations although farm A raises some hogs. Farm B is a dairy farm. Corn is grown on approximately 25% of each of these farms. All land in production on Farm D is planted to continuous corn and there is no livestock.

Reported excesses are based on estimated corn requirements of 1.1 pounds per bushel. Using estimated needs of 1.0 or 1.2 pounds per bushel, as discussed earlier, would decrease or increase needs, and hence, increase or decrease per acre excesses by about 15 pounds[4]. Timing losses associated with fall application of manure were estimated at 10% of the nitrogen in applied manure based upon discussions with soil scientists familiar with the

[4] The 15 pound range is larger than the range for the aggregate budgets because the yield goals of the individual farmers were higher than the average for the region and the county.

TABLE 4
NITROGEN(N) FROM LIVESTOCK - SOUTHEASTERN MINNESOTA
PRODUCED, LOST, AND AVAILABLE

Type of Animal	N Produced	Not Collected	Lost in Storage	Lost in Application	Applied
	1000 lbs. N				
Cattle:					
Dairy	34,482	1,724	11,007	1,087	20,664
All Other	36,781	15,234	9,887	583	11,077
Total	71,263	16,958	20,894	1,670	31,740
Hogs	16,558	828	5,458	514	9,758
Hens and Pullets	430	43	97	14	276
Total	88,251	17,829	26,449	2,198	41,775
Per Acre	129	26	39	3	61
% of Production		20	30	2	47

NOTES

[1] N production estimates are based upon estimates of the components (animal types and weights) of each available data category and N production estimates per animal. Livestock data was obtained from Minnesota Agricultural Statistics; per animal N production statistics were obtained from the Livestock Waste Facilities Handbook

[2] N loss estimates were based on estimated actual livestock and manure handling practices. Proportional losses given particular practices were obtained from the Livestock Waste Facilities Handbook.

TABLE 5
NITROGEN(N) FROM LIVESTOCK - FILLMORE COUNTY
PRODUCED, LOST, AND AVAILABLE

Type of Animal	N Produced	Not Collected	Lost in Storage	Lost in Application	Applied
	------1000 lbs. of N------				
Cattle:					
Dairy	5,670	283	1,810	179	3,398
All Other	8,450	3,500	2,271	134	2,545
	14,120	3,783	4,081	313	5,943
Hogs	5,262	263	1,735	163	3,101
Hens and Pullets	117	12	26	4	75
Total	19,499	4,058	5,842	480	9,119
Per Acre	101	21	30	2	47
% of Production		21	30	2	47

NOTES

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[1] N production estimates are based upon estimates of the components (animal types and weights) of each available data category and N production estimates per animal. Livestock data was obtained from Minnesota Agricultural Statistics; per animal N production statistics were obtained from the Livestock Waste Facilities Handbook.

[2] N loss estimates were based on estimated actual livestock and manure handling practices. Proportional losses given particular practices were obtained from the Livestock Waste Facilities Handbook.

TABLE 6
NITROGEN(N) FROM LIVESTOCK - DUSCHEE CREEK WATERSHED
PRODUCED, LOST, AND AVAILABLE

Type of Animal	N Produced	Not Collected	Lost in Storage	Lost in Application	Applied
	1000 lbs. N				
Cattle:					
Dairy	363	18	116	11	218
All Other	313	130	84	5	94
Total	676	148	200	16	312
Hogs	333	16	107	10	190
Hens and Pullets	*	*	*	*	*
Total	999	164	307	26	502
Per Acre	209	34	64	6	105
% of Production		16	31	3	50

NOTES

[1] N production estimates are based upon estimates of the components (animal types and weights) of each available data category and N production estimates per animal. Livestock data was obtained by the University of Minnesota Center for Urban and Regional Affairs through a survey of farmers in the watershed during 1986; per animal N production statistics were obtained from the Livestock Waste Facilities Handbook.

[2] N loss estimates were based on estimated actual livestock and manure handling practices. Proportional losses given particular practices were obtained from the Livestock Wate Facilities Handbook.

* less than 500 pounds.

area. Sutton, et al (1983) estimates losses at 25 to 50% for Indiana. Had 25% been used to estimate timing losses associated with fall application, available nitrogen provided by manure, given actual practices, would be reduced by 5, 22 and 5 pounds per acre on Farms A, B and C, respectively. The effect of the assumptions has the largest impact on the estimated excesses on farm B. The range of excesses on that farm, given actual practices, is 96 to 148 pounds per acre. The former reflects needs of 1 pound per bushel and timing losses of 10%; the latter reflects needs of 1.2 pounds per bushel and timing losses of 25%.

Differences in fertilizer application are essentially reflected in differences in yield goals. Farmers A, B, and C report reducing application of nitrogen on rotated acres, but not by as much as the recommended amount. Farmers A and C spread most of their collected manure on a portion of their corn acres, while farmer B spread all of it on corn acres. All three report little or no reduction in fertilizer application on those corn acres where manure was applied. Tables 7-9 present production and losses of nitrogen from animal wastes for farms A, B and C, respectively. Nitrogen production does not differ appreciably. The dairy operation (B) confines its animals and therefore collects an estimated 90% of the waste production. Much of the nitrogen produced by beef cattle falls in the pasture and is therefore uncollected. Farmer B's anaerobic pit results in a smaller proportional loss of collected nitrogen than does the more conventional open lots used by farmers A and C. Farmers B and C currently broadcast their manure in the fall, resulting in high application and timing losses. Farmer A incorporates his manure, reducing application losses, but applies it in the fall.

TABLE 7
NITROGEN(N) FROM LIVESTOCK - FARM A
PRODUCED, LOST, AND AVAILABLE
ACTUAL AND IMPROVED HANDLING PRACTICES

Type of Animal	N Produced[3]	Not Collected	Lost in Storage	Lost in Application	Applied	Lost in Field	Available to Crop
	lbs. N						
Actual Practices[2]							
Beef Cattle	21,800	14,570	3,255	98	3,157	316	2,841
Hogs	2,205	0	551	364	1,290	129	1,161
Total	23,285	14,570	3,806	462	4,447	445	4,002
Per Acre	194	121	32	4	37	4	33
Percent of Production		63	16	2	19	2	17
Improved Practices[1]							
Beef Cattle	21,080	14,570	1,432	51	5,027	0	5,027
Hogs	2,205	0	485	17	1,703	0	1,703
Total	23,285	14,570	1,917	68	6,730	0	6,730
Per Acre	194	121	16	1	56	0	56
Percent of Production		63	8	0	29	0	29

NOTES

1 "Improved practices" are a set which reduce storage, application, and application timing losses of N in manure. Specifically, manure is assumed to be stored in an anaerobic pit and injected once a year in the spring.

2 Currently, this farmer stores cattle manure in an open lot and incorporates it into corn land in the fall. Feeder pig manure is spread on pasture as it is generated. Timing losses are assumed to be 25% in both cases.

3 N produced is based upon reported 1986 livestock intensity and N production estimates per animal by weight and type obtained from the Livestock Waste Facilities Handbook.

TABLE 8
NITROGEN(N) FROM LIVESTOCK - FARM B
PRODUCED, LOST, AND AVAILABLE
ACTUAL AND IMPROVED HANDLING PRACTICES

Type of Animal	N Produced[3]	Not Collected	Lost in Storage	Lost in Application	Applied	Lost in Field	Available to Crop
	lbs. N						
Actual Practices[2]							
Dairy Cattle	28,650	2,865	5,673	3,520	16,592	1,660	14,932
Per Acre	249	25	49	31	144	14	130
Percent of Production		10	20	12	58	6	52
Improved Practices[1]							
Dairy Cattle	28,650	2,865	5,673	201	19,911	0	19,911
Per Acre	249	25	49	2	173	0	173
Percent of Production		10	20	0	70	0	70

NOTES

1 "Improved practices" are a set which reduce storage, application, and application timing losses of N in manure. Specifically, manure is assumed to be stored in an anaerobic pit and injected once a year in the spring.

2 Currently, this farmer stores cattle manure in an anaerobic pit and sprays it on corn ground (without incorporation) once a year in the fall.

3 N produced is based upon reported 1986 livestock intensity and N production estimates per animal by weight and type obtained from the Livestock Waste Facilities Handbook.

TABLE 9
NITROGEN(N) FROM LIVESTOCK - FARM C
PRODUCED, LOST, AND AVAILABLE
ACTUAL AND IMPROVED HANDLING PRACTICES

Type of Animal	N Produced[3]	Not Collected	Lost in Storage	Lost in Application	Applied	Lost in Field	Available to Crop
	lbs. N						
Actual Practices[2]							
Beef Cattle	29,140	22,659	3,240	729	2,512	251	2,261
Per Acre	374	291	42	9	32	3	29
Percent of Production		78	11	3	9	1	8
Improved Practices[1]							
Beef Cattle	29,140	22,659	1,426	51	5,004	0	5,004
Per Acre	374	291	18	1	64	0	64
Percent of Production		78	5	0	17	0	17

NOTES

1 "Improved practices" are a set which reduce storage, application, and application timing losses of N in manure. Specifically, manure is assumed to be stored in an anaerobic pit and injected once a year at planting.

2 Currently, this farmer stores cattle manure in an open lot and broadcasts it in late fall on land to be planted to corn.

3 N produced is based upon reported 1986 livestock intensity and N production estimates per animal by weight and type obtained from the Livestock Waste Facilities Handbook.

"Improved" vs. Current Practices

Table 3 and the second sections of Tables 7 through 9 present the farm level budgets assuming nitrogen conserving practices of handling fertilizer and manure.

All of the farmers currently incorporate or inject commercial fertilizer in the spring. Avoidable nitrogen losses, reflected in the differences between commercial fertilizer sources between Tables 2 and 3, are minimal. Further, those differences are related to high residue resulting from conservation tillage, rather than application methods or timing.

"Improved" manure handling practices involve storage of animal waste in an anaerobic pit with injection once a year in the spring. Using these methods, Farms A and C would approximately double available nitrogen from manure. Farm B, because it already has an anaerobic pit, would reduce application and eliminate timing losses, increasing available nitrogen from manure by about one third.

These results indicate the potential nutrients that could be made available to the crop, given current herd sizes and herd management. In all likelihood, adoption of all of these practices, particularly spring application of all manure, is not cost effective from the farmer's perspective.

Summary of Nitrogen Findings

Nitrogen available in Southeastern Minnesota exceeds amounts required for current acreages and yields of corn. These excesses appear to be quite unevenly distributed across farms, with the largest excesses on dairy farms.

These excesses appear to reflect failure to account for (and possibly effectively use) nitrogen from legumes and manure.

IV. ECONOMIC IMPLICATIONS

Two questions immediately arise from the results:

1. Why would livestock operators apply unneeded nitrogen? Apparently these farmers could increase their profits by reducing fertilizer applications and therefore costs without changing their manure handling methods.
2. Would livestock operators not further gain from adopting "improved" manure handling methods, further reducing the need for commercial fertilizer?

Current Practices

There are two possible answers to the first question:

- Farmers simply do not know the amount of nitrogen currently available in manure and carried over from legumes in rotation.
- Farmers' current choices are those which best meet their objectives, given available resources.

In fact, the failure to fully reduce fertilizer applications for amounts available from other sources likely reflects, in part, lack of awareness or disbelief of published or other reports as to amounts provided by these sources. In addition, there are reasons why farmers might find excess application of nitrogen consistent with their objectives.

Consider these reasons within the framework of a standard model of producer decisions. The producer's problem is to choose management practices that maximize objectives subject to resource constraints. Farmers face uncertainty from many sources, particularly prices and weather. They must also consider future impacts of today's decisions, so the problem is intertemporal in nature.

Expected profits are one of, if not the, most important objective farmers seek to maximize. Clearly, if it is cheaper to apply commercial fertilizer than to spread available manure, then spreading manure is inconsistent with this objective.

A ton of manure from dairy cattle contains about 14, 4 and 10 pounds of N, P and K, respectively (Sutton, 1983).[5] At nutrient prices of 15, 25 and 10 cents per pound, the nutrient value is about $4.10. Since the nitrogen is mineralized over several years, a portion of this value is not realized in the year of application. Further, if manure is applied at sufficiently high rates, one or more of the nutrients become redundant, further reducing the current value of the manure.

Consider farmers applying 140 pounds of nitrogen per acre in the anhydrous ammonia form and 180 pounds per acre of 9-23-30 starter fertilizer. At the above fertilizer prices, commercial fertilizer costs $39.18 per acre ($23.43 for 165 lbs. of nitrogen, $10.35 for P, and $5.40 for K) plus $5.50 per acre (typically reported custom application costs) for application of the anhydrous ammonia. To achieve this level of nitrogen with manure requires approximately 12 tons. To the extent a farmer can haul and spread manure for less than $3.75 a ton ($45 per acre), including labor and equipment costs, hauling available manure is cheaper than commercial fertilizer. (The $3.75 per ton value differs from the previous calculation, because the P and K in

[5] At time of application, with a solid handling system.

manure exceed the applications in commercial fertilizer and, to that extent, are considered redundant. If manure were substituted for only a portion of the commercial fertilizer, the value would be closer to the $4.10 per ton.)

If farmers choose not to spread manure on corn acres, they must dispose of it in other ways. Traditionally, this has meant spreading it on the field closest to the storage area. To determine if manure should be spread on all fields, the costs to be used are those additional costs of hauling and spreading on the more distant fields. One farmer in our sample spread no manure on some corn fields due to distance from the barn because he believed spreading costs exceeded the cost of custom applied fertilizer.

Most farmers consider risk or distribution of outcomes in choosing a set of practices. Further, many farmers are thought to be risk averse; that is, they prefer a sure outcome to a risky one with the same expected outcome. Stated another way, a risk averse individual would prefer a plan with lower expected value and lower risk to one with somewhat higher expected value and higher risk. The range of differences in expected value over which this would be true would depend primarily on the degree of risk aversion.

Based upon a sample of sorghum growers in Texas, SriRamaratnam et al. (1987) report that farmers perceive nitrogen as a risk reducing input. This is consistent with the perceptions of the farmers interviewed in our study. This implies that risk averse farmers would choose nitrogen input levels somewhat in excess of those that maximized expected profits, regardless of the source.

Farmers' consideration of risk has a further implication. Commercial fertilizer has certain nutrient content. The amount of nutrients actually provided by legumes and manure is less certain. Soil and manure analysis can reduce this uncertainty but not eliminate it. If farmers are risk averse, one would expect them to favor commercial fertilizer and, to the extent they utilized nitrogen from other sources, apply a total amount of nitrogen beyond that expected to meet crop needs. This uncertainty probably contributes substantially to the failure of many farmers to fully reduce commercial fertilizer applications by expected nutrients from other sources.

In summary, currently available nitrogen exceeds crop requirements for at least three reasons.

- There is a lack of knowledge about the magnitude of nutrients available from legumes and in animal wastes.
- The costs of commercial fertilizer may be less than the costs of spreading available manure.
- Farmers may resort to "over application" due to risk aversion.

IMPROVED PRACTICES

To consider all aspects of the second question would require a full analysis of the costs and benefits of adopting manure handling practices which increase available nitrogen; a task beyond the scope of this paper. However, it is possible to discuss some of the factors farmers must consider in choosing their manure handling practices.

Adopting our "improved" practices would require farmers A and C to install anaerobic pits with a capacity large enough to allow a single annual application. Farmer B has these facilities. All would need to invest in equipment for injection of the liquid manure. (Incorporating sprayed manure would substantially reduce losses from current practices on Farms B and C. Estimated application losses incorporating manure would be 1-5%, compared with 15-30% and 0-2% for broadcasted and injected manure, respectively[6]). All three farmers would need to switch application from late fall to spring.

Spring application of manure would require a substantial amount of labor and equipment time, just when the demand for that labor and equipment time is highest. Stated another way, labor and equipment transferred from other operations to manure spreading at or near planting time has a very high opportunity cost. In the fall, these opportunity costs are lower. The difference is likely to exceed the value of the nutrients lost (estimated at 10%).

Installing an anaerobic pit and possibly acquiring spreading equipment adds capital costs (depreciation and interest) to the hauling and spreading costs considered previously. A farmer whose objective is simply maximizing expected profits would need to consider whether the value of additional nutrients, at expected future nutrient prices, justifies the cost of acquiring the equipment. Of course, the ability of many farmers to make capital investments, particularly in times of economic stress, is severely constrained by the decline in value of farm assets.

If farmers consider risk in their objectives, and are risk averse, they may choose not to invest in storage facilities and spreading equipment even when the expected cost savings from the venture is positive. The value of nutrients gained is contingent upon uncertain future fertilizer prices. During the last several years, fertilizer prices have been quite volatile, rising dramatically from 1975 to 1982, and falling by as much as 50% since 1982.

[6] Livestock Waste Facilities Handbook.

POLICY IMPLICATIONS

What do our results imply for public agencies and others interested in improving water quality? Some of the options, given a desire to abate ground water pollution, include:

- Educate and persuade farmers to adopt practices which reduce inputs of nitrates and other contaminants of ground water.
- Regulate the use of inputs and outputs that affect water quality.
- Tax or subsidize inputs and outputs that affect water quality.[7]

Educational programs aimed at overall nitrogen management are likely to achieve success only if farmers perceive that they are better off by adopting suggested changes. The results imply the following about the potential success of educational programs:

- There are farmers who could be credibly convinced that their profits would be increased by more fully considering current sources of nitrogen other than commercial fertilizer. However, it would be difficult, for reasons cited above, to convince farmers to fully reduce commercial fertilizer applications by estimated amounts available from other sources.
- Educational programs aimed at overall nitrogen management are likely to achieve the most impact with dairy and livestock operators.
- While programs aimed at fertilization rates may have some impact, programs focusing only on commercial fertilizer handling practices

[7] Generally, contaminant emissions are regulated, taxed, or reductions thereof subsidized. Unfortunately, groundwater contaminants generated by individual farms cannot be feasibly measured, so inputs and outputs that affect the levels of pollution must be regulated, taxed or subsidized. Pollution from agricultural production generally falls into this "non-point source" pollution category.

appear to have limited potential. None of the farmers in our sample were aware of other farmers who applied nitrogen fertilizer in the fall or broadcast without incorporation.

Educational programs could also be aimed at increasing farmers' awareness and concern about the impacts of nitrates and other ground water contaminants on themselves and others. If successful, this approach would obtain results beyond those achieved by appealing to profit motives. Unfortunately, the current lack of information regarding the relationship of practices to ground water quality limits the potential of this approach.

Our work to date is insufficient to predict probable effects (response and impacts) of regulations and/or incentives aimed at changing practices to improve water quality. It does, however, permit some general observations, and raises some questions:

- Regulations limiting fertilizer use would, at least initially, have the largest financial impact on corn growers without livestock enterprises. Livestock operators appear to have the flexibility to substitute manure and legume rotations for commercial fertilizer. In the long run, if regulations were sufficiently tight, cash crop farmers would develop the ability to utilize nitrogen from other sources. Markets for manure might develop or corn farms may become mixed farms.
- Taxes on fertilizer would, in the short run, result in larger reductions in fertilizer use on mixed farms, and induce more judicious use of other nitrogen sources. In the longer term, sufficiently high taxes would produce results similar to regulations. Of course, taxes impose costs on farmers beyond the potential loss of profits associated with reducing fertilizer use. These costs may be substantial. Swanson, et al [1973]

and others have shown that economically optimal levels of fertilizer use are not particularly responsive to prices. This indicates that high taxes on fertilizer would be required to induce farmers to substantially reduce use.

Any policy aimed only at reducing commercial fertilizer use would result in increased use or substitution of nitrogen from other sources. Hence, a 25% reduction in nitrogen provided by commercial fertilizer would reduce nitrogen use by something less than 25% because of the substitution of other sources. Thus, since the "problem" is overall management of nitrogen, any policy aimed at changing practices, educational or otherwise, should consider all sources of nitrogen controlled by the farmer.

SUMMARY

Nitrogen availability for growing corn exceeds crop needs in the karst area of Southeastern Minnesota. The excesses appear to be concentrated on mixed farms, with dairy farms the most likely candidates for large excesses. Further, nitrogen conserving manure handling methods are available which could dramatically increase the nitrogen available from non-commercial sources. Commercial fertilizer application accounts for only 45 to 75 percent of nitrogen available to mixed farms. While farmers may reasonably choose not to reduce commercial fertilizer applications by the full amount of nitrogen available from other sources, the magnitude of our estimated excesses implies that educational programs could be successful in achieving some reduction in commercial fertilizer use and better management of other nitrogen sources.

Policies aimed at reducing nitrate contamination by regulating or taxing commercial fertilizer are not likely to achieve reductions in nitrogen applications equivalent to the reduction in commercial fertilizer use. Farmers will substitute other sources of nitrogen, such as manure, for commercial fertilizer. Financial burdens of taxes or regulations would likely be borne disproportionately, at least initially, by cash crop operators, since they would have fewer alternatives, while these farms may be making relatively smaller contributions to nitrates in ground water.

Clearly, knowledge regarding the relationships between farm practices and nitrates reaching groundwater will enhance our ability to analyze potential policies aimed at abatement. Is nitrogen leaching affected by nitrogen source? Improved manure handling reduces nitrogen losses. However, what does this imply about losses due to leaching? What is the relationship between tillage practices and leaching?

Knowledge regarding these relationships could also be used to provide farmers with some notion of how changing their practices would affect water supplies they and others use. These "costs" could then be factored into their nitrogen and other management decisions.

Further research aimed at predicting likely responses to and impacts of alternative fertilizer control policies also has high potential payoffs. How large a tax on fertilizer or subsidy on capital costs of manure handling equipment would be needed to significantly reduce fertilizer use or to induce farmers to adopt nitrogen conserving manure handling practices? What are the incentives for farmers to circumvent regulations on inputs or practices? Answers to these and related questions would assist policy makers in identifying changes in practices likely to achieve improvements ground water quality and in designing and implementing policies aimed at achieving the changes.

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APPENDIX A, TABLE 1
AGGREGATE NITROGEN BUDGETS
SOUTHEASTERN MINNESOTA, FILLMORE COUNTY,
AND DUSCHEE CREEK WATERSHED

	SE MN	County	Watershed
	Pounds N/Acre		
N needed to grow average yield	127	118	118
Sources:			
Commercial Fertilizer	112	112	112
Soybean credits	7	7	2
Alfalfa credits	9	6	10
Applied Manure	61	47	105
Total Sources	190	172	229
Excess N Per Acre	63	54	118

Crop Needs	SE MN	County	Watershed
Average corn yield	115	107	107
N Factor (lbs./bu.)	1.1	1.1	1.1
Lbs.N needed to grow average yield	127	118	118

Commercial Fertilizer	SE MN	County	Watershed
Est lbs. N Fert Applied to Corn[1]	76,807,500	21,722,700	--
Corn Acres Planted	638,800	193,400	--
Lbs. N/Acre	112	112	112

Soybean Credits	SE MN	County	Watershed
Last year soybeans acres harvest	165,600	44,900	382
Lbs.N credit/acre soybeans	30	30	30
Corn Acres Planted	683,800	193,400	4,794
Soybean credits (lbs.N/ac. corn)	7	7	2

(Continued next page)

APPENDIX A, TABLE 1 (page 2 of 5)
Aggregate Nitrogen Budgets
Southeastern Minnesota, Fillmore County,
and Duschee Creek Watershed

	Alfalfa Credit		
	SE MN	County	Watershed
Alfalfa Acres	310,300	60,700	2,453
Est alfalfa rot to corn (33% alf)	102,399	20,031	809
Lbs. N credit/acre alfalfa	60	60	60
Corn acres planted	683,800	193,400	4,794
Alfalfa credit (lbs. N/ac.corn)	9	6	10

	Manure		
	SE MN	County	Watershed
All cattle and calves(#)	598,700	122,000	5,251
Dairy cattle(#)	164,200	27,000	1,728
Lbs. N/Yr./Cow	210	210	210
Lbs. N produced by dairy cattle	34,482,000	5,670,000	362,880
Est proportion collected	.95	.95	.95
Lbs. N collected	32,757,900	5,386,500	344,736
Est ave prop lost in storage	.34	.34	.34
Lbs. N available for application	21,751,246	3,576,636	228,905
Est ave prop lost in app	.05	.05	.05
Lbs. N applied	20,663,683	3,397,804	217,460

(Continued next page)

APPENDIX A, TABLE 1 (page 3 of 5)
Aggregate Nitrogen Budgets
Southeastern Minnesota, Fillmore County,
and Duschee Creek Watershed

	SE MN	County	Watershed
	---	Numbers	---
Cattle other than milk cows			
Beef cows	75,400	23,500	871
Cattle & calves on feed	40,400	8,800	326
Others	318,700	62,700	2,325
Est components-other			
Bulls 1%	3,187	627	23
Heifers-dairy rep 31%	98,797	19,437	721
Heifers-beef rep 14%	44,618	8,778	326
Heif & steers-other 10%	31,870	6,270	233
Calves 44%	140,228	27,588	1,023
Est lbs. N by type			
Beef cows	9,877,400	3,078,500	114,164
Cattle & calves on feed	4,383,400	954,800	35,408
Bulls	669,270	131,670	4,883
Heiffers-dairy rep	10,714,535	2,113,774	78,388
Heiffers-beef rep	4,011,158	789,142	29,265
Heiffers & Steers-other	2,469,925	487,141	18,065
Calves	4,655,570	894,679	33,178
Lbs. N produced by other cattle	36,781,258	8,449,706	313,351
Est proportion collected	.59	.59	.59
Lbs. N collected	21,547,198	4,950,007	183,567
Est ave prop lost in storage	.46	.46	.46
Lbs. N available for application	11,659,675	2,678,561	99,332
Est ave prop lost in app	.05	.05	.05
Lbs. N applied	11,076,691	2,544,633	94,366

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APPENDIX A, TABLE 1 (page 4 of 5)
Aggregate Nitrogen Budgets
Southeastern Minnesota, Fillmore County,
and Duschee Creek Watershed

	SE MN	County	Watershed
Hogs	----------------	Number----------------	
Sows	87,900	28,100	5,120
Other	420,900	105,900	--
Piglet crop	682,700	218,200	5,500
N Prodn-pigs	12,749,423	4,050,338	102,094
N prodn-sows	3,808,821	1,211,953	220,826
Lbs. N produced by hogs	16,558,224	5,262,291	322,919
Est proportion collected	.95	.95	.95
Lbs. N collected	15,730,332	4,999,176	306,773
Est ave prop lost in storage	.35	.35	.35
Lbs. N available for application	10,271,907	3,264,462	200,323
Est ave prop lost in app	.05	.05	.05
Lbs. N applied	9,758,312	3,101,239	190,307
Hens and Pullets	406,000	111,000	423
Lbs. N/Hen/Yr	1.06	1.06	1.06
Lbs. N produced by hens & pullets	429,751	117,494	448
Est proportion collected	.90	.90	.90
Lbs. N collected	386,776	105,744	403
Est ave prop lost in storage	.25	.25	.25
Lbs. N available for application	290,082	79,308	302
Est ave prop lost in app	.05	.05	.05
Lbs. N applied	275,578	75,343	287

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APPENDIX A, TABLE 1 (page 5 of 5)
Aggregate Nitrogen Budgets
Southeastern Minnesota, Fillmore County,
and Duschee Creek Watershed

	SE MN	County	Watershed
Manure Recap			
Lbs. N produced	88,251,253	19,499,491	999,598
Not collected	17,829,047	4,058,063	164,118
Lbs. N collected	70,422,206	15,441,427	835,479
Lost in storage	26,449,297	5,842,460	306,617
Lbs. N available for application	43,972,909	9,598,967	528,862
Lost in application	2,198,646	479,948	26,443
Lbs. N applied	41,774,264	9,119,019	502,419
Recap per acre			
Corn acres planted	683,800	193,400	4,794
Lbs. N Production/acre	129	101	209
Not collected	26	21	34
Lbs. N Collected/Acre	103	80	174
Lost in storage	39	30	64
Lbs. N Available for app/acre	64	50	110
Lost in application	3	2	6
Lbs. N Applied/acre	61	47	105

1 95% of per corn acre N fertilizer sales in the six county area. County and watershed use was estimated to be equal to the southeastern Minnesota average.

APPENDIX A, TABLE 2
INDIVIDUAL FARM NITROGEN(N) BUDGET
ACTUAL CURRENT PRACTICES

	Farm A	Farm B	Farm C	Farm D
	--Pounds N/acre--			
N needed to meet yield goal	164	154	164	151
Sources:				
Commercial Fertilizer	155	130	145	138
Soybean carryover	26	--	--	--
Alfalfa carryover	10	27	17	--
Applied manure	33	130	29	--
Total sources	224	287	191	138
Excess N per Acre	60	133	27	-13

	Crop Needs A	B	C	D
Yield goal	150	140	150	138
N factor (lbs./bu)	1.1	1.1	1.1	1.1
Lbs. N needed to meet yield goal	164	154	164	151

	Commercial Fertilizer A	B	C	D
Application 1 per acre				
Time of application	spring	spring	spring	spring
Factor	1.00	1.00	1.00	1.00
Type of fertilizer	anhydrous	uan	anhydrous	anhydrous
Factor	1.00	1.00	1.00	1.00
Application method	inject	incorp	inject	inject
Residue level	medium	high	high	very high
Factor	1.00	.98	.95	.91
Nitrication inhibitor	no	no	no	no
Lbs of N; or	81	119	136	138
Lbs. fertilizer; and				
Percentage N				
N loss factor	1.00	1.00	1.00	1.00
Lbs. available N/acre	81	117	129	125

(Continued next page)

APPENDIX A, TABLE 2 (Page 2 of 5)
Individual Farm Nitrogen Budget
Actual Current Practices

	A	B	C	D
Application 2 per acre				
Time of application	spring	spring	spring	spring
Factor	1.00	1.00	1.00	1.00
Type of fertilizer	starter	starter	starter	starter
Factor	1.00	1.00	1.00	1.00
Application method	incorp	incorp	incorp	incorp
Residue level	medium	medium	high	very high
Factor	1.00	1.00	.98	.95
Nitrication inhibitor	no	no	no	no
Lbs. of n; or				
Lbs. fertilizer; and	150	150	180	138
Percentage N	9	9	9	10
Loss factor	1.00	1.00	1.00	1.00
Lbs. available N/acre	14	14	16	13
Application 3 per acre				
Time of application	sidedress	--	--	--
Factor	1.00	--	--	--
Type of fertilizer	uan	--	--	--
Factor	1.00	--	--	--
Application method	sur band	--	--	--
Residue level	low	--	--	--
Factor	1.00	--	--	--
Nitrication inhibitor	no	--	--	--
Lbs of N	60	--	--	--
Loss factor	1.00	--	--	--
Lbs. available N/acre	60	--	--	--
Total lbs. available N/acre	155	130	145	138

Soybean Credits

	A	B	C	D
Last yr soybean acres harv	104	--	--	--
Lbs. N credit/acre soybeans	30	--	--	--
Corn acres planted	120	115	78	366
Soybean credit (lbs. N/acre corn)	26	--	--	--

(Continued next page)

APPENDIX A, TABLE 2 (Page 3 of 5)
Individual Farm Nitrogen Budget
Actual Current Practices

	Alfalfa credits			
	A	B	C	D
Alfalfa rot to corn	20	52	23	--
N credit/acre alfalfa	60	60	60	--
Corn acres planted	120	115	78	366
Alfalfa credits (lbs. N/acre corn)	10	27	17	--

	Manure			
	A	B	C	D
Dairy cattle	--	185	--	--
Est # 1000 lb. units	--	191	--	--
Lbs. N produced/unit/year	--	150	--	--
Lbs. N produced by dairy cattle	--	28,650	--	--
Beef cattle	200	--	419	--
Est #1000 lb. units	170	--	235	--
Lbs. N produced/unit/year	124	--	124	--
Lbs. N produced by beef cattle	21,080	--	29,140	--
Lbs. N produced by cattle	21,080	28,650	29,140	--
Lbs. N collected	6,510	25,785	6,481	--
Storage method	open lot	anaer pit	open lot	--
Storage factor	.50	.78	.50	
Lbs. N available for application	3,255	20,112	3,240	--
Application method	incorp	broadcast	broadcast	--
Application factor	.97	.83	.78	--
Lbs. N applied	3,157	16,593	2,511	--
Time of application	late fall	late fall	late fall	--
Time factor	.90	.90	.90	--
Lbs. N available to crop	2,841	14,932	2,261	--

(Continued next page)

APPENDIX A, TABLE 2 (Page 4 of 5)
Individual Farm Nitrogen Budget
Actual Current Practices

	A	B	C	D
Hogs				
Sows	--	--	--	--
Feeders	300	--	--	--
Piglet crop	--	--	--	--
Est # 1000 lb. units	13	--	--	--
Lbs. N produced/unit/year	165	--	--	--
Lbs. N produced by hogs	2,205	--	--	--
Lbs. N collected	2,205	--	--	--
Storage method	scr/haul	--	--	--
Storage factor	.75	--	--	--
Lbs. N available for application	1,654	--	--	--
Application method	broadcast	--	--	--
Application factor	.78	--	--	--
Lbs. N applied	1,290	--	--	--
Time of application	late fall	--	--	--
Time factor	.90	--	--	--
Lbs. N available to crop	968	--	--	--
<u>Manure Recap</u>				
Lbs. N produced	23,285	28,650	29,140	--
Not collected	14,570	2,865	22,659	--
Lbs. N collected	8,715	25,785	6,481	--
Lost in storage	3,806	5,673	3,240	--
Lbs. N available for application	4,909	20,112	3,240	--
Lost in application	462	3,520	729	--
Lbs. N applied	4,447	16,593	2,511	--
Application timing loss	445	1,160	251	--
Lbs. N available to crop	4,002	14,932	2,261	--

(Continued next page)

APPENDIX A, TABLE 2 (Page 5 of 5)
Individual Farm Nitrogen Budget
Actual Current Practices

Recap per acre corn acres planted	120	115	78	366
Lbs. N Production/acre	194	249	373	--
Not collected	121	25	290	--
Lbs. N Collected/acre	73	224	83	--
Lost in storage	32	49	41	--
Lbs. N Available for appl/acre	41	175	41	--
Lost in application	4	31	9	--
Lbs. N Applied/acre	37	144	32	--
Application timing loss	4	14	3	--
Lbs. N Available to crop/acre	33	130	29	--

APPENDIX A, TABLE 3
INDIVIDUAL FARM NITROGEN(N) BUDGET
IMPROVED PRACTICES OF HANDLING
COLLECTED MANURE AND FERTILIZER

	A	B	C	D
	----------------Pounds N/acre----------------			
N needed to meet yield goal	164	154	164	151
Sources:				
Commercial fertilizer	155	133	152	151
Soybean credits	26	--	--	--
Alfalfa credits	10	27	17	--
Manure	56	173	64	--
Total sources	247	333	233	151
Excess per acre	83	179	69	--

Crop Needs

	A	B	C	D
Yield goal	150	140	150	138
N factor (lbs./bu)	1.1	1.1	1.1	1.1
Lbs. N needed to meet yield goal	164	154	164	151

Commercial Fertilizer

	A	B	C	D
Application 1 per Acre				
Time of application	spring	spring	spring	spring
Factor	1.00	1.00	1.00	1.00
Type of fertilizer	anhydrous	anhydroas	anhydrous	anhydrous
Factor	1.00	1.00	1.00	1.00
Application method	inject	incorp	inject	inject
Residue level	medium	medium	medium	medium
Factor	1.00	1.00	1.00	1.00
Nitrication inhibitor	no	no	no	no
Lbs. of N; or	81	119	136	138
Lbs. fertilizer; and				
Percentage N				
Loss factor	1.00	1.00	1.00	1.00
Lbs. available N/acre	81	119	136	138

(Continued next page)

APPENDIX A, TABLE 3 - Page 2 of 5
Individual Farm Nitrogen Budget
Improved Practices of Handling
Collected Manure and Fertilizer

	A	B	C	D
<u>Application 2 per acre</u>				
Time of application	spring	spring	spring	spring
Factor	1.00	1.00	1.00	1.00
Type of fertilizer	starter	starter	starter	starter
Factor	1.00	1.00	1.00	1.00
Application method	incorp	incorp	incorp	incorp
Residue level	medium	medium	medium	medium
Factor	1.00	1.00	1.00	1.00
Nitrication inhibitor	no	no	no	no
Lbs. of N; or				
Lbs. fertilizer; and	150	150	180	138
Percentage N	9	9	9	10
Loss factor	1.00	1.00	1.00	1.00
Lbs. available N/acre	14	14	16	14
<u>Application 3 per acre</u>				
Time of application	sidedress	--	--	--
Factor	1.00	--	--	--
Type of fertilizer	uan	--	--	--
Factor	1.00	--	--	--
Application method	sur band	--	--	--
Residue level	low	--	--	--
Factor	1.00	--	--	--
Nitrication inhibitor	no	--	--	--
Lbs. of N; or	60	--	--	--
Lbs. fertilizer; and				
Percentage N				
Loss factor	1.00	--	--	--
Lbs. available N/acre	60	--	--	--
Total lbs. available N/acre	155	133	152	151

<u>Soybean credits</u>

	A	B	C	D
Last yr soybean acres harv	104	--	--	--
N credits/acre soybeans	30	--	--	--
Corn acres planted	120	115	78	366
Soybean credits (lbs. N/acre corn)	26	--	--	--

(Continued next page)

APPENDIX A, TABLE 3 - Page 3 of 5
Individual Farm Nitrogen Budget
Improved Practices of Handling
Collected Manure and Fertilizer

	Alfalfa credits A	B	C	D
Alfalfa rot to corn	20	52	23	--
N credit/acre alfalfa	60	60	60	--
Corn acres planted	120	115	78	366
Alfalfa credit (Lbs. N/acre)	10	27	17	--

	Manure A	B	C	D
Dairy cattle	--	185	--	--
Est # 1000 lbs. units	--	191	--	--
Lbs. N produced/unit/year	--	150	--	--^R
Lbs. N produced by dairy cattle	--	28,650	--	--
Beef cattle	200	--	419	--
Est # 1000 lb. units	170	--	235	--
Lbs. N produced/unit/year	124	--	124	--
Lbs. N produced by beef cattle	21,080	--	19,140	--
Lbs. N produced by cattle	21,080	28,650	29,140	--
Lbs. N collected	6,510	25,785	6,481	--
Storage method	anaer pit	anaer pit	anaer pit	--
Storage factor	.78	.78	.78	--
Lbs. N available for application	5,078	20,112	5,055	--
Application method	inject	inject	inject	--
Application factor	.99	.99	.99	--
Lbs. N applied and available	5,027	19,911	5,004	--

(Continued next page)

APPENDIX A, TABLE 3 - Page 4 of 5
Individual Farm Nitrogen Budget
Improved Practices of Handling
Collected Manure and Fertilizer

	A	B	C	D
Hogs				
Sows	--	--	--	--
Feeders	300	--	--	--
Piglet crop	--	--	--	--
Est # 1000 lb. units	13	--	--	--
Lbs. N produced/unit/year	165	--	--	--
Lbs. N produced by hogs	2,205	--	--	--
Lbs. N collected	2,205	--	--	--
Storage method	anaer pit	--	--	--
Storage factor	.78	--	--	--
Lbs. N available for application	1,703	--	--	--
Application method	inject	--	--	--
Application factor	.99	--	--	--
Lbs. N applied and available	1,703	--	--	--
Manure recap				
Lbs. N production	23,285	28,650	29,140	--
Not collected	14,570	2,865	22,659	--
Lbs. Collected N	8,715	25,785	6,481	--
Lost in storage	1,917	5,673	1,426	--
Lbs. N available for application	6,798	20,112	5,055	--
Lost in application	68	201	51	--
Lbs. N applied and available	6,730	19,911	5,004	--

(Continued next page)

APPENDIX A, TABLE 3 - Page 5 of 5
Individual Farm Nitrogen Budget
Improved Practices of Handling
Collected Manure and Fertilizer

Recap per acre				
Corn acres planted	120	115	78	366
Lbs. N Production/acre	194	249	374	--
Not collected	121	25	291	--
Lbs. N Collected/acre	73	224	83	--
Lost in storage	16	49	18	--
Lbs. N Available for app/acre	57	175	65	--
Lost in application	1	2	1	--
Lbs. N Applied and avail/acre	56	173	64	--