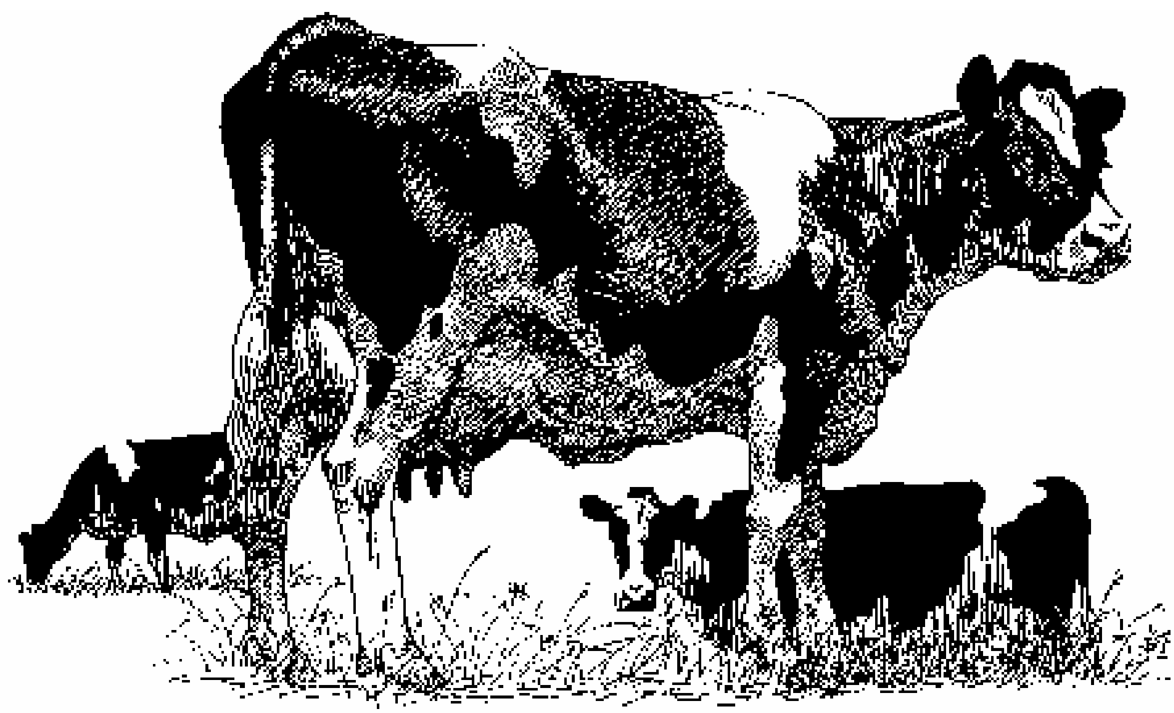
# Dairy Farmers Located on the Karst Region of Southeast MN



## General Information

County Educators (MN Extension Service) from Fillmore, Goodhue, Houston, Olmsted, Wabasha, and Winona Counties were contacted and individually interviewed in July, 1993. Purpose of the interviews was: to inform them of the specifics of the project and overall goals; obtain pertinent county information (i.e. dairy density distributions in relation to Karst regions); and potential candidates (farmers) and their agronomic management skills as perceived by the County Educator. County Educators also served as an important link between the farmers and the researchers; Educators commonly made personnel telephone calls to the potential participants after the introduction letter (Appendix A-1) was mailed. Fifteen to twenty contacts, classified as either "Low", "Average" , or "High" management skills, were collected in each of the six counties. Introduction letters, signed by the Commissioner of Agriculture, were mailed out to the farmers in late July and early August, 1993. The letter's intent was to identify : the overall LCMR project; the purpose of the nutrient assessment; why they were selected; and what types of information and amount of their time would be necessary to successfully complete the project.

## Nutrient Management Data Collection

Inventory forms and data base design were patterned after a previous successful project[1] . A copy of the inventory form is included in Appendix A-1. Timing, rates, method of applications were collected for all nitrogen (N) and phosphate ($P_2O_5$) inputs (fertilizers, manures, and legumes) on **a field-by-field basis for all acres owned or rented**. There were 921 management areas in the entire study. A management area is defined as a field or group of fields (managed by the same producer) that had the same nutrient inputs. If an individual field was not managed uniformly, it would be broken down into separate management areas. Soil and manure testing results were also collected if available. Nutrient inputs and yields were specific for the 1993 cropping season. Crop types and manure applications (starting in the fall of 1992) were also collected from the 1992 season for purposes of 1993 nitrogen crediting. Long term yield data generally reflected the past 3 to 5 years. Livestock census and other specifics for the entire farm (i.e. types of manure storage systems, total farm sizes) were also recorded.

[1]Effective Nitrogen and Water Management for Water Quality Sensitive Regions of Minnesota, LCMR 1991-93

## Farm Size and Crop Characteristics of the Selected Farms

Sixty-three (63) farmers were interviewed during August and September, 1993. Total inventoried acres by county (and number of farms per county) are as follows: Fillmore 6,200 (11), Goodhue 5,100 (11), Houston 4,400 (11), Olmsted 3,900 (10), Wabasha 3,000 (10), and Winona 3,200 acres (10). Total area covered by the interviews was 25,700 acres; 17,350 acres were identified as tillable (Table A.1.1). The average farm size was 405 acres with 274 acres in cropland and an average herd size of 68 cows.

**Table A.1.1. General description of all farms participating in the 1993 Southeast MN nutrient management assessment.**

| | | Total Acreage Inventoried | | | Average Acreage by Farm | | | |
|---|---|---|---|---|---|---|---|---|
| County | Farm | Total(1) | Crop(2) | Noncrop | Total(1) | Crop(2) | Noncrop | Average Herd Size |
| | | ................................ Number of Acres | | | ................................... | | | (Cows) |
| Fillmore | 11 | 6212 | 4120 | 2092 | 565 | 374 | 191 | 67 |
| Goodhue | 11 | 5089 | 3594 | 1495 | 463 | 327 | 136 | 72 |
| Houston | 11 | 4374 | 2398 | 1976 | 398 | 218 | 180 | 55 |
| Olmsted | 10 | 3853 | 3034 | 819 | 385 | 303 | 82 | 84 |
| Wabasha | 10 | 3011 | 1999 | 1012 | 301 | 200 | 101 | 59 |
| Winona | 10 | 3160 | 2233 | 927 | 316 | 223 | 93 | 68 |
| **Mean** | | **4,283** | **2,519** | **1,387** | **405** | **274** | **130** | **68** |
| **Total** | **63** | **25,699** | **17,378** | **8,321** | | | | |
| **Percent Total** | | **100** | **67.6** | **32.4** | | | | |

(1) Includes owned, rented and rented out acres.
(2) Includes fertilized or manured pasture and set-aside acres.

Corn (46%), alfalfa (32%), small grains (12%), and soybeans (6%) accounted for over 96% of the cropland acres (Figure A.1.1). In contrast, the cropland distribution across all farms in the six county area[2] was comprised of corn (49%), alfalfa (22%), soybeans (16%), small grains (10%), and miscellaneous crops (3%) (Figure A.1.2). The selected farms were skewed towards alfalfa acres and less soybeans than the overall six county distribution. County specific data is given in Table A.1.2.

[2]MN Agricultural Statistics 1994. National Agricultural Statistics Service, St. Paul, MN.

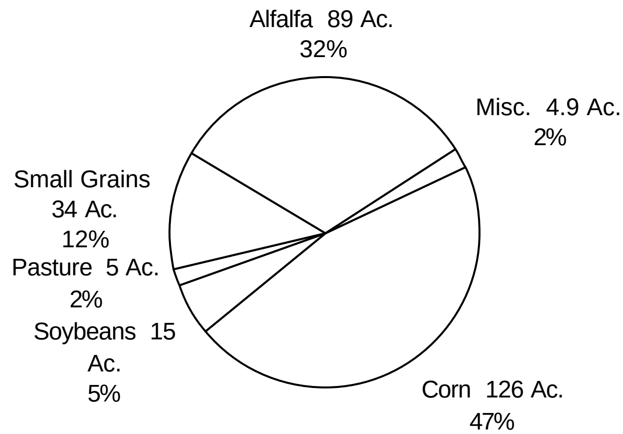



Figure A.1.1. Crop type distribution across all cropland acres of the selected farms. Acres listed are the averages per farm.

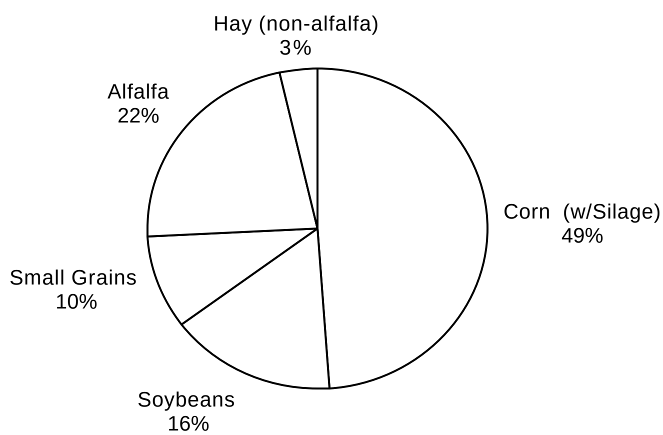



Figure A.1.2. Crop type distribution across **all** 1993 cropland acres in Fillmore, Goodhue, Houston, Olmsted, Wabasha, and Winona Counties (MN Agricultural Statistics, 1994).

| Table A.1.2. Average distribution of cropland acres per farm by county - 1993 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **County** | **Corn** | **Soybeans** | **Alfalfa** | **Small Grains** | **Sweet Corn** | **Other** | **Fertilized Pasture** | **TOTAL** |
| | **In Acres** | | | | | | | |
| Fillmore | 186 | 42 | 96 | 40 | 0 | 3.9 | 7.3 | 374 |
| Goodhue | 142 | 17 | 103 | 40 | 14.4 | 9.4 | 0 | 327 |
| Houston | 97 | 8 | 76 | 32 | 0 | 1.5 | 4.4 | 218 |
| Olmsted | 148 | 11 | 102 | 29 | 0 | 1.6 | 12 | 303 |
| Wabasha | 80 | 6 | 80 | 31 | 0 | 0 | 3.0 | 200 |
| Winona | 104 | 8 | 76 | 31 | | 1.2 | 3.0 | 223 |
| **Mean** | **126** | **15** | **89** | **34** | **2.4** | **2.4** | **5.0** | **274** |
| **Total** | **7,992** | **987** | **5,595** | **2,146** | **158** | **191** | **309** | **17,378** |
| **% by Crop Type** | **46.0** | **5.7** | **32.2** | **12.3** | **0.9** | **1.0** | **1.8** | |

## Commercial Fertilizer Use Characteristics on Selected Farms

Corn accounted for 92% of the total N commercial fertilizer use (Figure A.1.3) and 94% of the total corn acreage received commercial N fertilizer. Average fertilizer N rate on corn acres was 90 lb/A; this rate is calculated as the means across all commercially fertilized corn acres regardless of past manure or legume N credits. Total N inputs will be discussed later in the "Nitrogen Balances and Economic Considerations" section. Alfalfa, small grains, and soybeans received 19, 20, and 42 lb/N/A, respectively, however the total acreage of any of these crops receiving commercial N is very limited (Table A.1.3 and Figure A.1.5). Phosphate rates on corn and alfalfa were 30 and 34 lb/A, respectively (Table A.1.3). Over 93% of the $P_2O_5$ fertilizer purchased on the farms was applied to these two crops (Figure A.1.4).

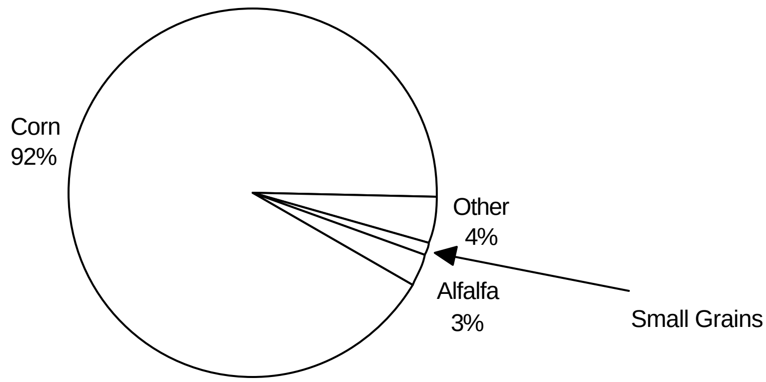



Figure A.1.3. Distribution of commercial nitrogen fertilizer by crop type. Total nitrogen supplied by fertilizer was 730,000 pounds across all farms.

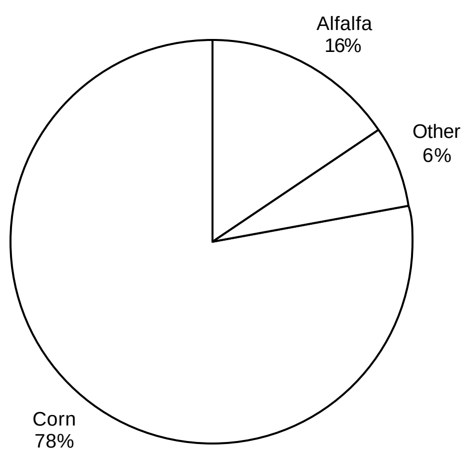



Figure A.1.4. Distribution of $P_2O_5$ fertilizer by crop type. Total $P_2O_5$ supplied by fertilizer was 285,000 pounds across all farms.

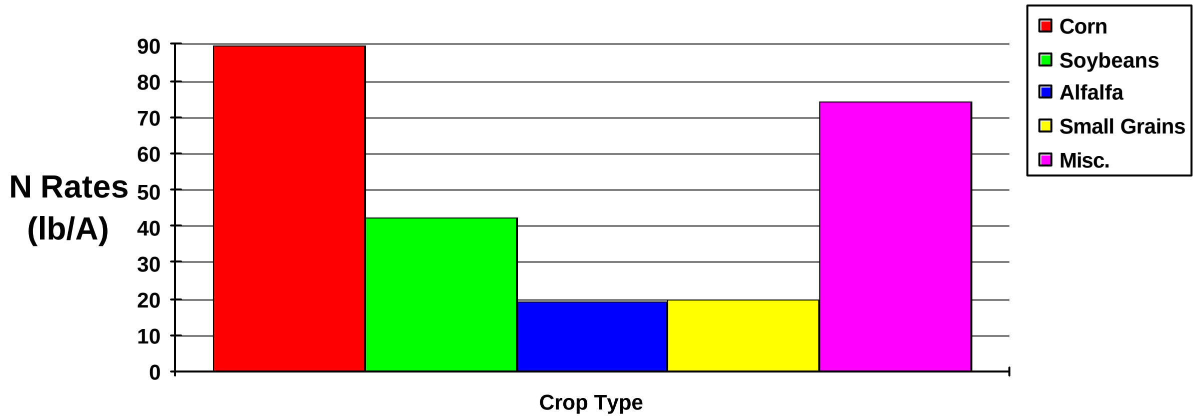



Figure A.1.5. Average N fertilizer rates across fertilized acres by crop type.

**Table A.1.3. Distribution of commercial nitrogen and phosphate applications on cropland - 1993**

| Crop | Acres Receiving N Fertilizer | Total N Applied (LBS X 1000) | Acres Receiving $P_2O_5$ Fertilizer | Total Applied $P_2O_5$ (LBS X 1000) |
|---|---|---|---|---|
| | | | | |
| Corn | 7,495 | 671.7 | 7,508 | 222.3 |
| Soybeans | 165 | 7.0 | 165 | 4.2 |
| Alfalfa | 1,027 | 19.7 | 1,283 | 44.2 |
| Small Grains | 364 | 7.3 | 459 | 9.9 |
| Other | 321 | 23.9 | 163 | 4.3 |
| | | | | |
| **TOTALS** | **9,372** | **730** | **9,578** | **284.9** |
| | | | | |

Timing of N fertilizer applications is an important consideration in maximizing fertilizer use efficiency and minimizing environmental effects. There has been a great deal of concern about fall N applications in the Karst areas of Minnesota. Fall applied N is not recommended[3] under any circumstances. In this study, there was **no fall fertilization on corn** (Figure A.1.6) and less than 3% of all remaining N fertilizers used on non-corn crops was fall applied. Even common phosphate fertilizers, such as 18-46-0, 9-23-30 and 7-21-7, were almost exclusively spring applied.

Based on MDA tonnage sales reports[4] (Figure A.1.7), it was previously believed that fall-application was still a relatively common practice. Sales data indicate that approximately 23%

[3] G.W. Randall and M.A. Schmitt, 1993. Best Management Practices for Nitrogen Use in Southeastern MN. . AG-FO-6126-B.

[4] MN Department of Agriculture is responsible for tracking county level fertilizer sales based on dealer information.

of the N is purchased in the fall. It appears that farmers are buying fertilizers in the fall for price advantages and tax purposes however the products are being spring applied.

Another important BMP for this region is to apply N as a spring preplant N on corn using anhydrous ammonia or urea. These two forms of N account for approximately 74% of the total commercial use (Figure A.1.8). Granulars[5] accounted for another 15% of the applied commercial N. UAN[6] is not an ideal source for preplant application. This product accounts for less than 10% of the overall sales and, although details regarding the timing of the application of this product are not yet known, the rate per application is approximately 50 lb/N/A. It is speculated that most of the usage is a either as a herbicide carrier and for sidedress applications. Negative environmental impacts from this type of use is probably minimal.

Producers are recommended to apply sidedress applications prior to the corn reaching a height of 12". Over 91% of the fertilizer N is applied prior to the corn reaching a height of 8". Producers are highly motivated to apply N as a sidedress prior to the 12" height due to difficulties in physically clearing the crop canopy with the required fertilizer/tillage equipment.

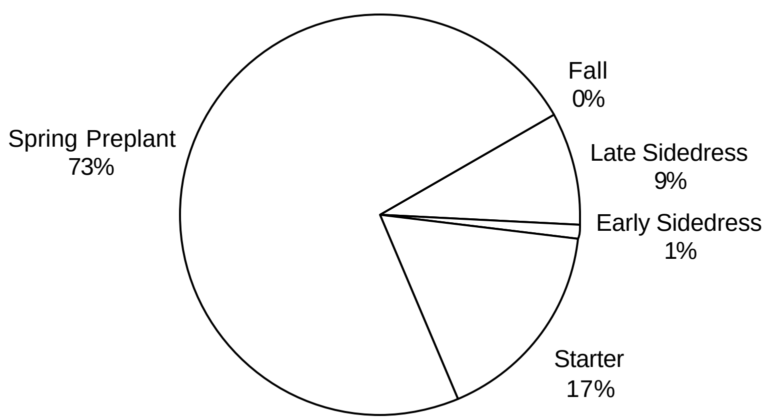



Figure A.1.6. Timing of N fertilizer applications across all crop types.

[5] Granular fertilizers represent a large array of various formulations, excluding urea, which are dominantly ammonium based.

[6] Urea Ammonium Nitrate (28% N by weight).

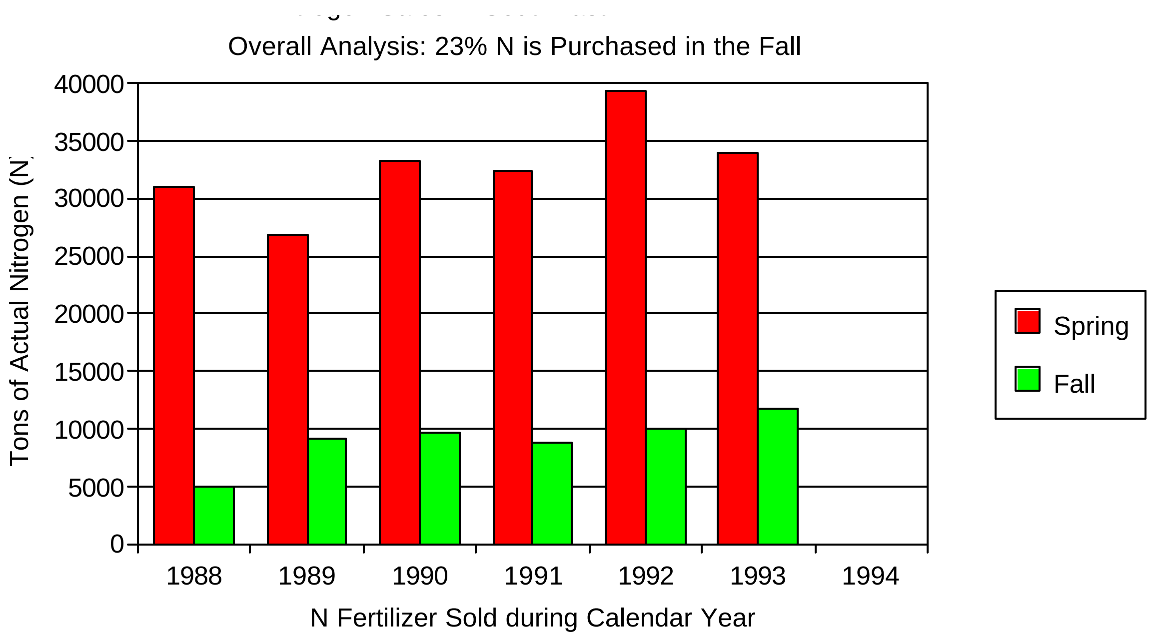



Figure A.1.7. County based N fertilizer sales during 1988-93 for Fillmore, Goodhue, Houston, Olmsted, Wabasha, and Winona counties. Data provided by the MN Department of Agriculture.

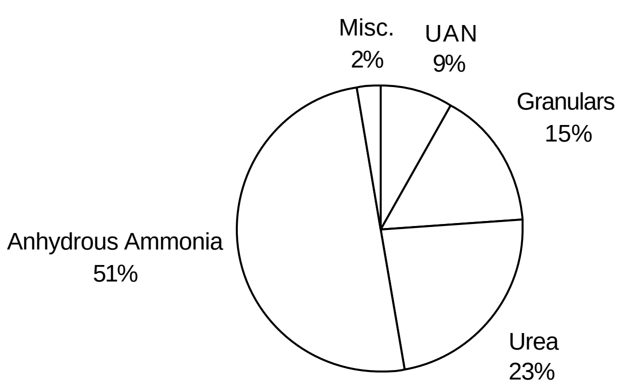



Figure A.1.8. Contributions of N from all fertilizer sources from the 63 selected farms.

The use of nitrification inhibitors can be helpful in controlling either leaching losses (coarse-textured soils) or denitrification during periods of near-saturated conditions on the fine-textured soils such as those that dominate much of southeast MN. Generally inhibitor use would not be recommended in this region of the state. No inhibitors were used with any N source, however, one producer had used the product with applications of liquid manure.

## Livestock and Manure Characteristics of the Selected Farms

Factors directly affecting nutrient availability from land applied manure (including manure storage, types, manure amounts being generated, application methods, incorporation factors and rates) were also quantified to complete the "whole farm" nutrient balance. These farms were dominantly dairy with an average herd size of 68 cows. Over 10,000 dairy animals (cows, calves, heifers, and steers) were inventoried. A complete animal inventory, including nitrogen and $P_2O_5$ produced and collected, are summarized in Table A.1.4.

**Table A.1.4. 1993 livestock numbers, and manure N and $P_2O_5$ produced and collected by livestock types in sample population.**

| Livestock Type | Livestock Number | Manure Nitrogen Produced | Manure Nitrogen Collected | Manure $P_2O_5$ Produced | $P_2O_5$ Collected |
|---|---|---|---|---|---|
| | | Pounds X 1000 | | Pounds X 1000 | |
| Dairy Cows | 4,594 | 895.8 | 692.7 | 362.9 | 280.6 |
| Calves & Heifers | 4,936 | 474.6 | 318.4 | 190.4 | 127.3 |
| Dairy Steers | 868 | 130.2 | 104.2 | 52.9 | 42.3 |
| Boars | 3 | 0.1 | 0.1 | 0.1 | 0.1 |
| Sows & Litters | 45 | 1.4 | 1.4 | 1.1 | 1.1 |
| Feeders (20 - 50 pounds) | 6,473 | 0.9 | 0.9 | 0.7 | 0.7 |
| Finishers (50 -240 pounds) | 6,643 | 30.2 | 30.2 | 22.9 | 22.9 |
| Bulls | 7 | 1.1 | 0.6 | 0.8 | 0.4 |
| Beef Cows & Calves | 224 | 27.5 | 15.5 | 21 | 1.8 |
| Beef Feeders | 169 | 12.2 | 6.5 | 9 | 4.8 |
| | | | | | |
| **TOTAL** | **23,962** | **1,574** | **1,170** | **662** | **492** |

Estimated amounts of N and $P_2O_5$ **per farm** produced from all livestock were 25,000 and 10,500 pounds, respectively (Figure A.1.9). Dairy cows, calves and heifers generated approximately 86% of the associated N and $P_2O_5$ produced through manure (Figure A.1.10).

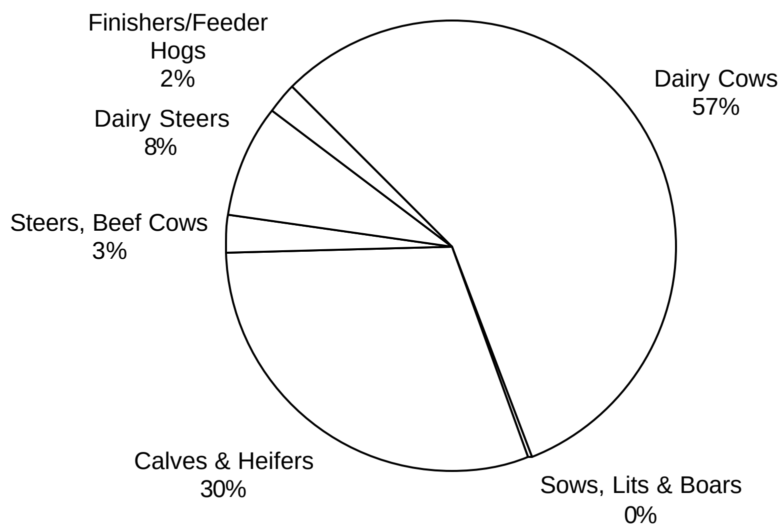



Figure A.1.9. Amounts of nitrogen (total) generated by animal types across all selected farms. Total N produced per farm was 25,000 pounds.

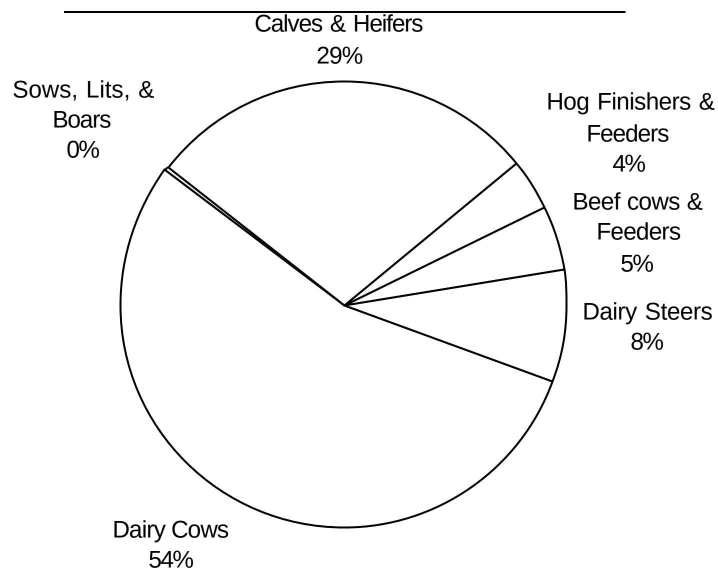



Figure A.1.10. Amounts of $P_2O_5$ generated by animal types across all selected farms. Total P produced per farm was 10,500 pounds.

Types of storage systems available for producers is an important consideration in efficiently retaining nutrients and allowing enough storage to field apply the manure in an environmentally safe manner. Twenty six (26) farms had liquid systems; the remaining 37 farms were dominantly daily scrape and haul operations. For purposes of this report, the following definitions were used: *Daily Scrape and Haul*-No storage available, manure is hauled generally on a daily basis. Common in dairy operations with stanchion or tie-stall barn designs; *Paved and Unpaved Pads*-Areas where solid manure is stacked on either the ground or cement pads to allow storage through the winter months until fields are accessible for spreading; *Paved and Unpaved Lots*-Cement or gravel covered areas that confine cattle. Manure (solid) is often hauled once or twice a year although some are cleaned monthly: *Animal Barns*- Buildings used to house livestock. The floors can either be cement, such as in a normal frame barn, or commonly a dirt floor often found in pole barns. Manure (solid) is often hauled in spring and fall, although the barns housing young calves are usually hauled more frequently; *Earthen Pits*- A majority of these pits are designed to meet Minnesota Pollution Control Agency and Natural Resource Conservation Service standards. Bottoms are frequently lined with compacted clay or other near-impervious material. Pits are usually emptied once or twice a year and are not covered; and *Slurry Store*-Above ground steel tanks which are generally emptied once or twice per year. Tanks are generally not covered.

Amounts of N and P collected, lost in storage, and amounts retained for land application are summarized by collection systems in Table A.1.5. Based on the N retained after collection (Figure A.1.11), the dominant collection systems of southeast MN are; animal barns(24%), daily scrape and haul systems (19%), earthen pits (19%) and slurrystore systems (16%). It appears that producers have the equipment facilities to store roughly three-fourths of the manure (based on retained N) and shouldn't be subjected to applying manure during poor weather conditions. Daily scrape and haul systems pose difficult en-vironmental challenges and field-applied losses after are high if not properly incorporated.

**Table A.1.5. Manure N and $P_2O_5$ collected and storage losses by all livestock on all farms in 1994**

| | Nitrogen Pounds X 1000 | | | Phosphate Pounds X 1000 | | |
|---|---|---|---|---|---|---|
| **Livestock Type** | **Collected** | **Lost** | **Retained** | **Collected** | **Lost** | **Retained** |
| Daily Scrape/Haul | 216 | 54 | 162 | 87.5 | 0 | 87.5 |
| Unpaved Lot | 80.8 | 40.4 | 40.4 | 32.9 | 09.8 | 23.1 |
| Paved Lot | 71.1 | 35.6 | 35.5 | 31.9 | 09.6 | 22.3 |
| Animal Barn | 274.9 | 82.8 | 192.1 | 116.6 | 0 | 116.6 |
| Pit Under Barn | 73.4 | 16.1 | 57.3 | 30.7 | 0 | 30.7 |
| Concrete Tank | 36.3 | 11.1 | 25.2 | 14.6 | 0 | 14.6 |
| Slurrystore | 189.8 | 41.8 | 148 | 76.9 | 0 | 76.9 |
| Unpaved Pad | 9.4 | 2.8 | 6.6 | 3.8 | 0 | 3.8 |
| Earthen Pit (open) | 143.6 | 43.1 | 100.5 | 63.7 | 0 | 63.7 |
| Earthen Pit (covered) | 75.2 | 22.5 | 52.7 | 33.3 | 0 | 33.3 |
| **SUBTOTAL** | **1,170.5** | **350.2** | **820.3** | **491.9** | **19.4** | **472.5** |

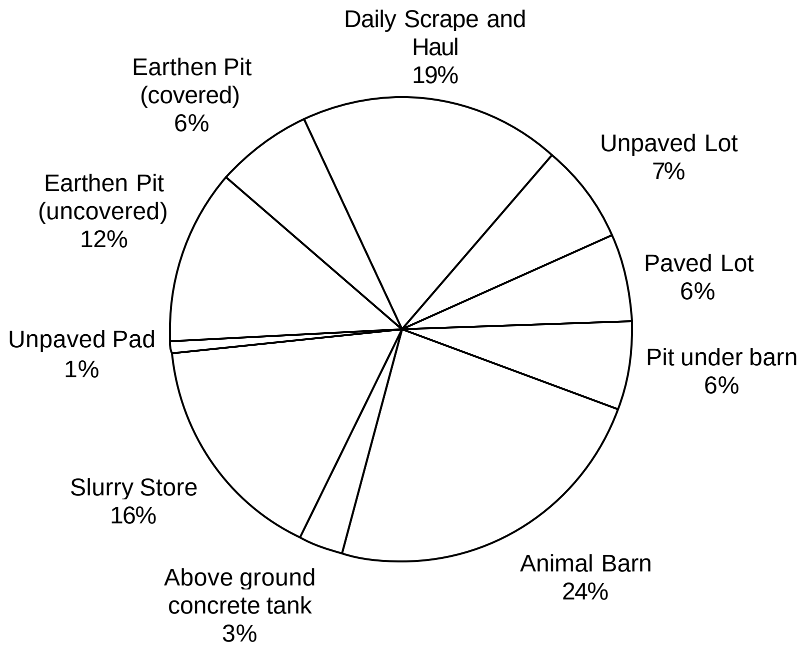



Figure A.1.11. Contributions of total nitrogen retained after storage by manure collection systems.

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Nutrient losses from collection and storage were estimated from accepted guidelines[7] for each individual storage system. Losses as a function of application methods and timing factors were calculated on a field-by-field basis (Table A.1.6). Manure generated a total of 407,000 lb of "first year available" N. This represents 6,500 lb/N/farm.

The fate of manure-N has been summarized in a simple flow diagram (Figure A.1.12). This diagram simplifies the complexities associated with N from excretion to "plant available". Almost 85% (on a weight basis) of the "first year available" N is applied to corn. Alfalfa (5%), small grain (5%) and soybeans (4%) received the bulk of the difference (Figure A.1.13).

Manure testing is a critical component in nutrient management planning. Approximately 15% of the producers had done some manure testing prior to this project. Usually these producers had tested the manure only once. Participants were offered manure and well water testing as part of the program. Due to the high variability found in manure analysis, individual tests greatly enhanced the value of the on-farm nutrient balance. Forty-six manure analysis were performed and the results from all types of systems is summarized in Table A.1.7.

[7] Livestock Waste Facilities Handbook, Midwest Plan Services, Iowa State University, Ames, Iowa. 1985.

| Table A.1.6. Distribution of applied manure to cropland, application and timing losses, and manure plant available nitrogen in 1993 | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Manure Nitrogen Applied Pounds X 1,000** | | | **Nitrogen Losses Pounds X 1,000** | | | |
| **Crop** | **Total** | **$NH4^+$ (Inorganic )** | **Organic N** | **Mineralized Organic N 1st Yr. Avail** | **Application Losses** | **Timing Losses** | **Manure-N First Yr. Available** |
| | **Pounds Manure Nitrogen X 1000** | | | | | | |
| Corn | 667.7 | 334.0 | 333.6 | 100.5 | 78.7 | 16.1 | 339.8 |
| Soybeans | 32.3 | 16.4 | 16 | 4.8 | 5.5 | 0.2 | 15.4 |
| Alfalfa | 38.9 | 19.8 | 19 | 5.7 | 3.9 | 0.6 | 21 |
| Small Grains | 44.7 | 22.4 | 22.4 | 6.7 | 7.7 | 0.4 | 21 |
| Other | 21.8 | 10.8 | 11 | 3.6 | 4.2 | 0.1 | 10 |
| | | | | | | | |
| **TOTAL** | **805** | **403** | **402** | **121** | **100** | **17** | **407** |

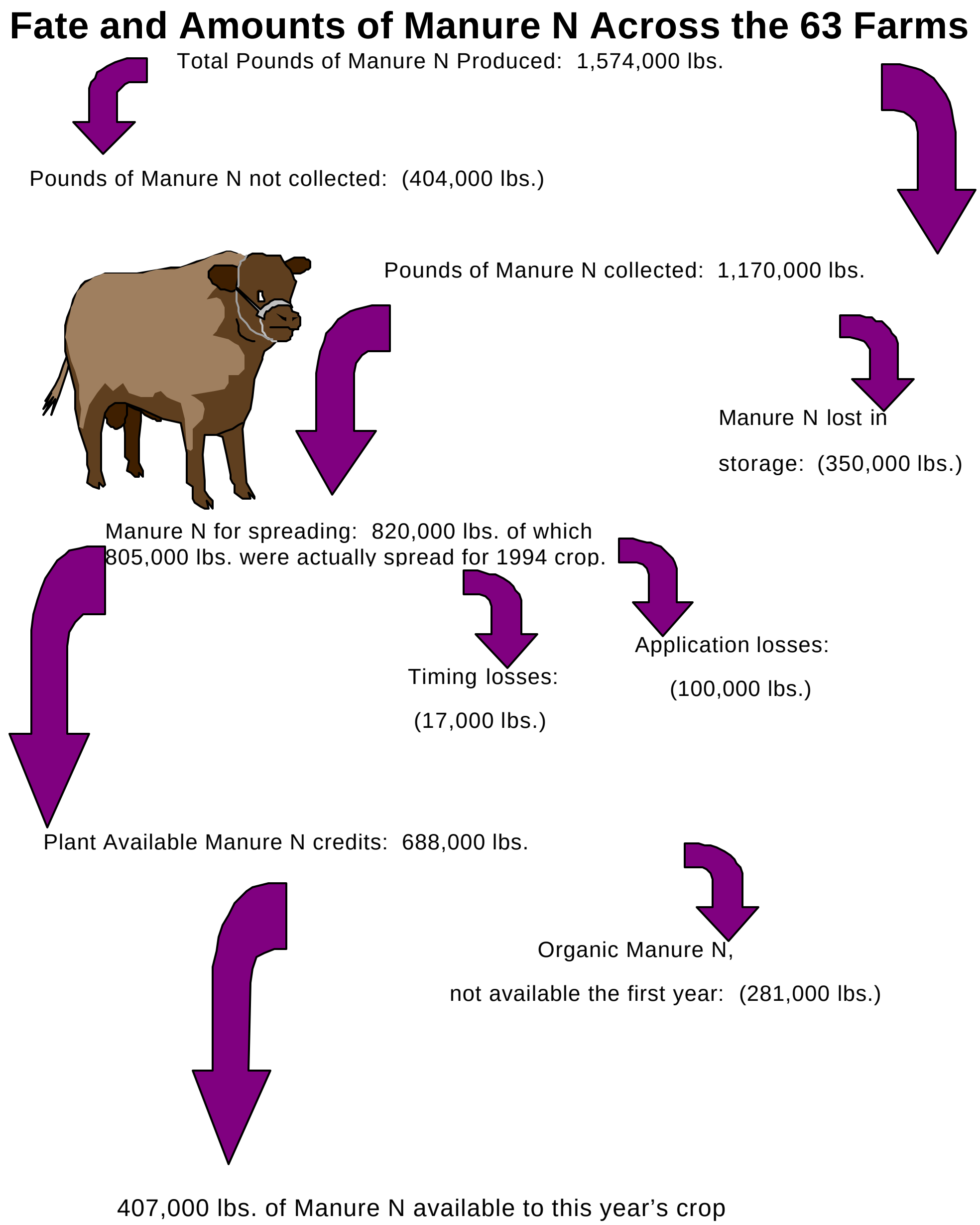


Figure A.1.12. Fate of manure-N across all storage and management factors.

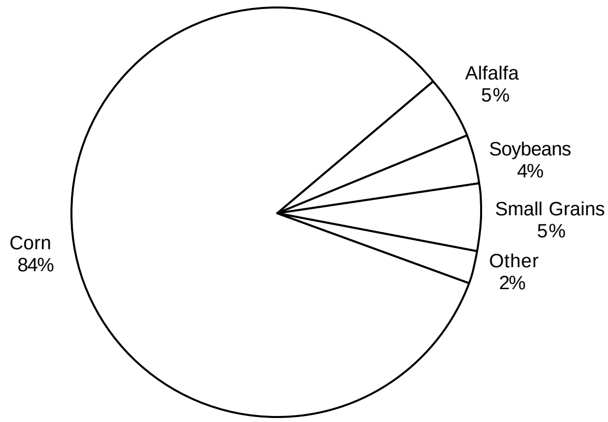


Figure A.1.13. Distribution of "first year available" nitrogen by crop type calculated on a weight basis.

Table A.1.7. Manure testing results summarized by collection systems.

| System Description | Number of | Nitrogen | | | Phosphate | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Lbs per Ton | Samples | Min. | Ave | Max. | Min. | Ave | Max. | Min. | Ave | Max. |
| Daily Scrape & Haul | 19 | 8 | 18 | 63 | 5 | 10 | 33 | 3 | 12 | 62 |
| Unpaved Lot | 3 | 8 | 10 | 13 | 5 | 6 | 6 | 2 | 7 | 13 |
| Paved Lot | 1 | 7 | 7 | 7 | 4 | 4 | 4 | 5 | 5 | 5 |
| Animal Barn | 4 | 10 | 11 | 14 | 7 | 8 | 9 | 3 | 7 | 11 |
| **Lbs per 1000 Gallon** | | | | | | | | | | |
| Pit Under Barn | 3 | 39 | 42 | 45 | 20 | 21 | 24 | 26 | 28 | 30 |
| Cement Tank | 3 | 10 | 14 | 19 | 3 | 4 | 7 | 12 | 20 | 34 |
| Slurry store | 4 | 27 | 34 | 41 | 12 | 17 | 22 | 20 | 24 | 28 |
| Earthen Pit (Covered) | 1 | 48 | 48 | 48 | 36 | 36 | 36 | 19 | 19 | 19 |
| Earthen Pit (Open) | 6 | 3 | 26 | 48 | 2 | 12 | 23 | 3 | 20 | 38 |
| Lagoon | 2 | 16 | 21 | 26 | 7 | 11 | 12 | 14 | 17 | 20 |

Manure test results from daily scrape and haul (19 samples) and liquid systems (19 samples) are illustrated in Figure A.1.14A and A.1.14B, respectively. Samples were highly variable particularly in the daily haul systems. Nutrient values with the sample group were generally higher than University of MN values. Liquid nutrient values were somewhat more consistent. This data is additional evidence of the high variability from farm to farm and manure testing is highly recommended.

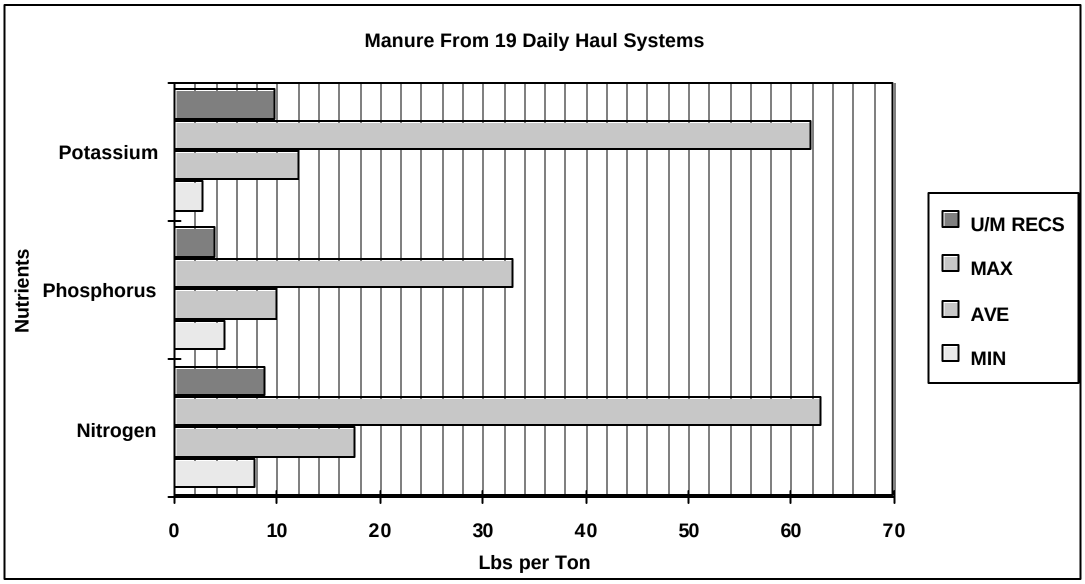


Figure A.1.14A. Nutrient values from 19 daily scrape and haul systems. University of MN average values are also included for comparison.

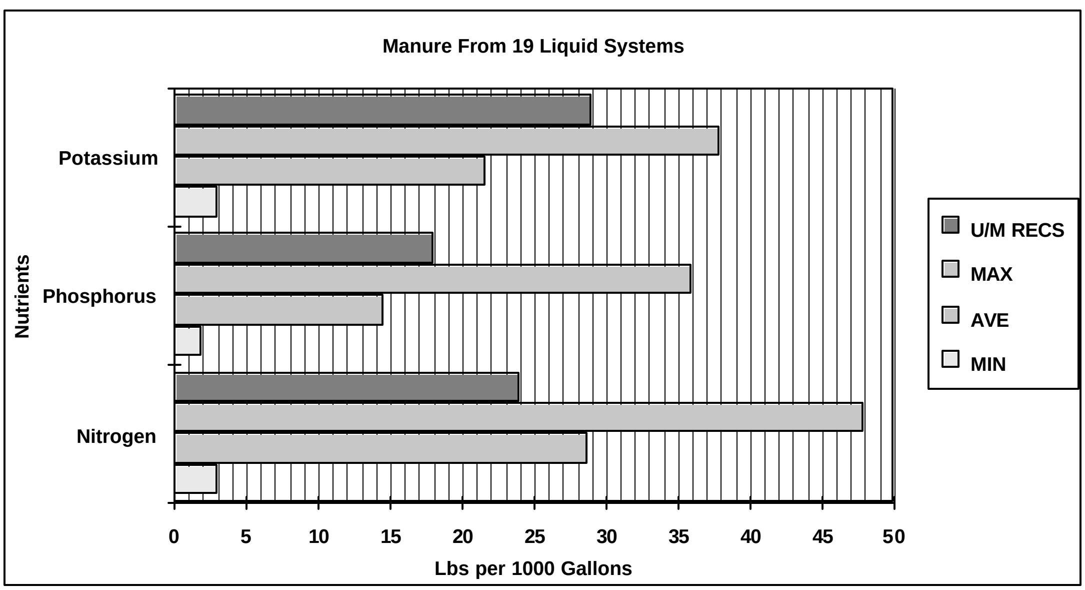


Figure A.1.14B. Nutrient values from 19 liquid systems (mixed systems). University of MN average values are also included for comparison.

## Relative Importance of N and P Sources on the Selected Farms

Commercial fertilizer (49%), manure (27%), and legume[8] (24%) contributed a total of 1,489,000 pounds of "first year available" N across all farms. Commercial fertilizer (38%) and manure (62%) contributed a total of 757,400 pounds of $P_2O_5$.

Commercial fertilizer (49%), manure (25%), and legume (26%) contributed a total of 1,364,000 pounds of "first year available N" to **corn acres** (Figure A.1.15). This is an average N rate of 167 lb/A across all corn acres. Contributions from organic sources (accounting for a total of 50% of the inputs) is considerably higher in southeast MN than in other locations of the state. Proper crediting for these sources is critical in maintaining economic and environmental balances.

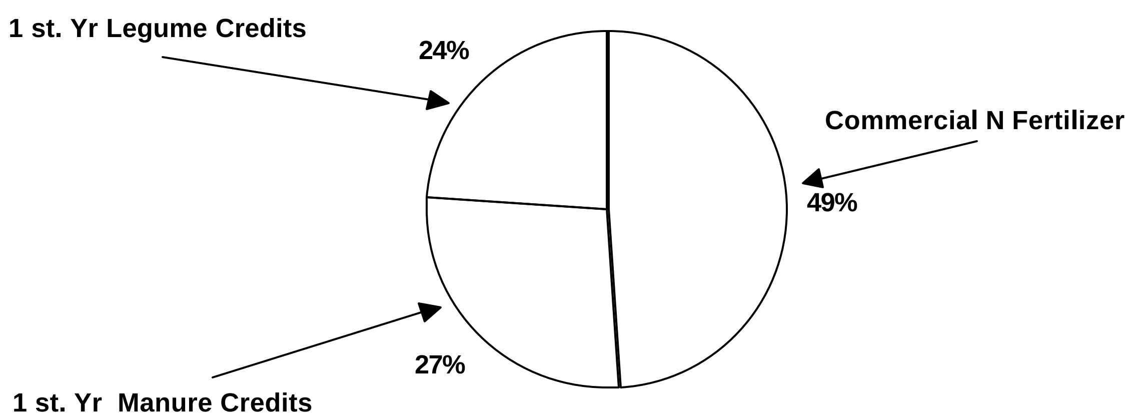


Figure A.1.15. Relative contributions from fertilizers, manures and legumes on first year available N across all corn acres. Average N input across all corn acres 167 lb/A.

[8] Approximated value; total legume credits has been calculate however the value across all crops has not yet been determined.

## Nitrogen Balances and Economic Considerations

The corn yield goal across all six counties was 147 bushels/A. Current University of Minnesota N recommendations to fulfill this goal is 135 lb/N/A (Figure A.1.16). It is important to note that these recommendations[9] are based on information that was not available to producers during the 1993 cropping season. Fertilizer rates have been decreased from previous recommendations. In 1990[10], N recommendations for 150 bushel corn following a Group 2 previous crop (crops with no residual N credit such as corn) would have been between 180 and 150 lb/A for soil organic matter groups of low-to-medium and high, respectively. In 1994, 120 lb/N/A and 150 lb/N/A would have been recommended for 131-150 and 151-170 bushel corn (now classified as medium to high soil organic matter).

Factoring in all appropriate credits from fertilizer, legumes and manures, there was an over-application rate of 53 lb/N/A. Within this report, averages across fields (on a county basis) have been reported. More detailed analysis will follow which will "weight" the data to account for the wide range in field sizes.

These numbers are somewhat conservative in nature due to the fact that only "first year credits" from manure are included in the analysis. A vast majority of the producers did not have adequate records from the previous year (1992[11]) to accurately credits these sources. Also the producers generally did not have sufficient information regarding alfalfa stand densities prior to terminating the crop therefore an average credit of 100 lb/A was assumed. A previous soybean crop is now given a 40 lb/A credit. We inadvertently used a 30 pound credit which would have been correct several years ago. Since the amount of acres in beans is minimal in this sample population, the error is minimal. Based only on the N fertilizer replacement value, proper crediting could save these producers approximately $10 to $11/A assuming no additional transportation and labor costs.

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[9] G.Rehm, M. Schmitt and R. Munter. 1994. Fertilizer recommendations for agronomic crops in Minnesota. BU-6240-E.

[10] G.Rehm and M. Schmitt 1990. Fertilizer recommendations for agronomic crops in Minnesota. AG-MI-3901.

[11] Referring to any manure applications prior to those made in the fall of 1992.

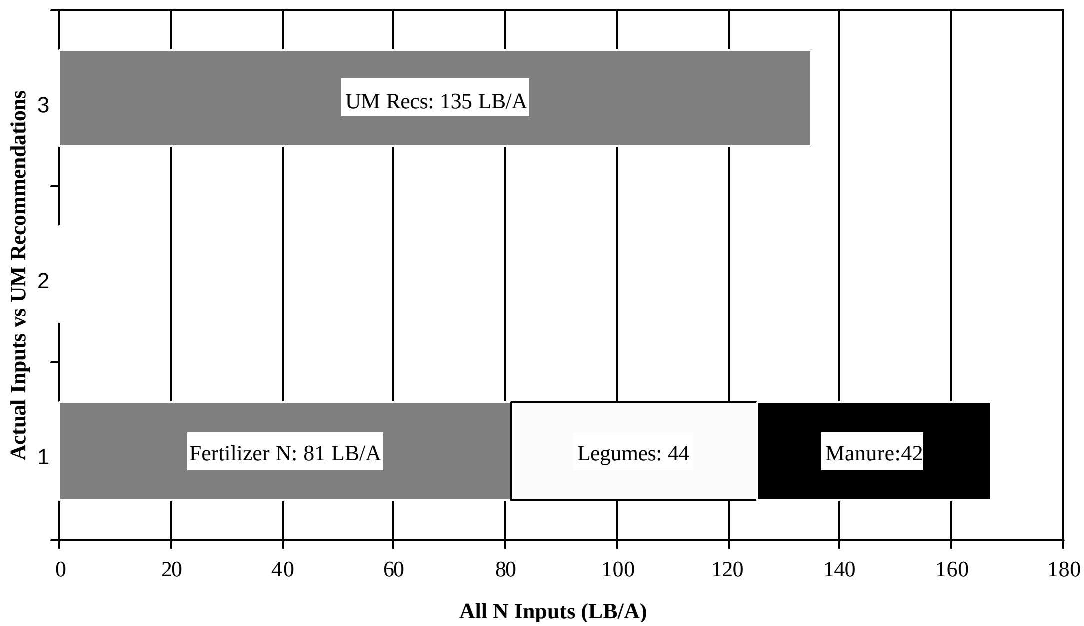


Figure A.1.16. Crop N requirements based on University of MN recommendations in comparison to actual N inputs (fertilizer, legumes, and manure) across all corn acres. Total corn area in this analysis was 7,992 acres.

Balances were examined in more detail by lumping the **corn acreage** into six different scenarios:

**Scenario 1: N from fertilizer only; no manure or legume credits;**
**Scenario 2: Previously alfalfa (1992); no manure applied;**
**Scenario 3: Previously soybeans (1992); no manure applied;**
**Scenario 4: Previously a non-legume crop, manure applied;**
**Scenario 5: Previously a legume crop (1992), manure applied;**
**Scenario 6: Previously alfalfa (1991).**

Nitrogen balances for all corn acres are broken down into these scenarios in Table A.1.8. Fertilizer N rates specific to each scenario is illustrated in Figure A.1.17. Rates in scenario 1 (no legumes, no manure) averaged 122 lb/A. One method to determine the credits attributed to the various organic contributions is to compare the subsequent commercial rates. **The following comments are based completely on the net differences in fertilizer N inputs comparing corn fields receiving only fertilizer N to the other scenarios:**

* Producers reduced N fertilizer by 49 lb/A for the "first year" alfalfa credits (N rate averaged 73 lb/A);

* Crediting for soybeans was extremely limited;

* Producers also significantly reduced fertilizer inputs on manured fields. Fertilizer N rates in scenario 4 (non-legume, manure applied) and scenario 5 (legume, manure applied) were reduced by 45 lb/A and 72 lb/A, respectively. These translate into reduction of 37 and 59%, respectively, in comparison to acres receiving only commercial N;

* Second year crediting for alfalfa is an important consideration in this region of the state. This scenario accounted for approximately 15% of the total corn acreage. Producers were reducing fertilizer N rates by 18 lb/A.

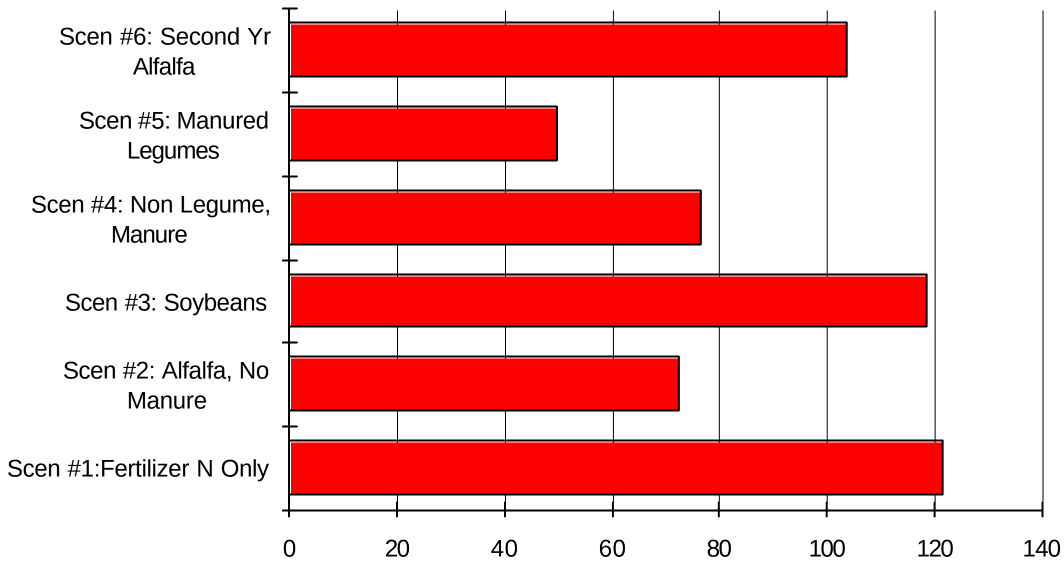


Figure A.1.17. Commercial fertilizer N rates on corn by management scenario.

Factoring in legume and manure credits into the process on a field-by-field basis, the amounts in excess[12] of 1994 University of MN recommendations are illustrated in Figure A.1.18. One of the huge advantages of the technique developed through the nutrient assessment process is the ability to examine in great detail the nutrient balances and make some inferences on where the biggest gains in water quality can be obtained through focused educational programs. Nitrogen balances are given in Table A.1.8.

12 In all scenarios, the balance was excess rather that a shortage.

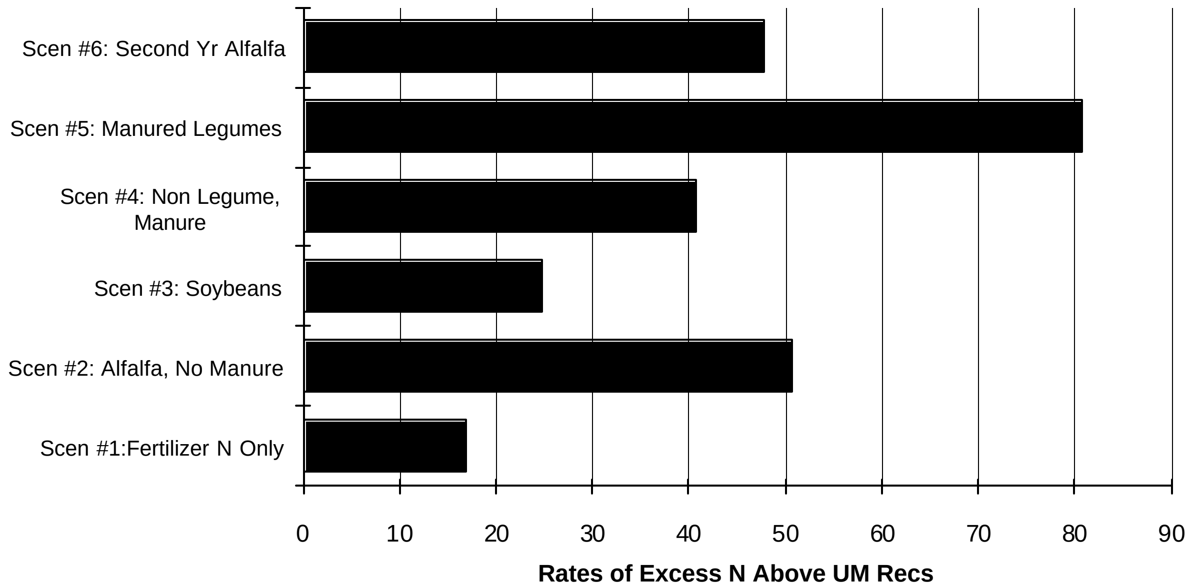


Figure A.1.18. Amounts of N in excess of 1994 University of Minnesota recommendations across the different management scenarios. Analysis includes all 7,992 acres.

As previously mentioned, the UM recommendations have been in the stage of transition over the past 5 years. In scenario #1, producers would have been very close to recommendations made in 1990. Using the new recommendations, producers were over-applying by 17 lb/A. Over-application rates in scenarios 2 through 4 ranged from 25-50 lb/A. Clearly the scenario where producers most severely over-applied N was on previous legume crops which received manure applications prior to corn production. Under-estimation of alfalfa credits was similar for both first and second year crediting.

Acreage distributions and N balances were then divided into two additional categories; ABOVE and BELOW UM recommendations. Data are given in Tables A.1.8B and A.1.8C respectively.  Seventy-six (76%) of the total corn acres were classified into the ABOVE category. Excess amounts of N averaged 70 lb/Acre. The remaining acres (24%) were classified as BELOW UM recommendations. Shortage amounts of N average 39 lb/A and it is interesting to note that most of this shortage fell into scenario 1.

Viewing the distribution of excess N from a water quality perspective, a helpful indicator is the cumulative excess N values found in Table A.1.8A. These figures factor in both the total acres of any given scenario as well as the rate of excess (shortage) of N. Clearly where producers could gain the most N credits and make the biggest impact on water quality is to take the credits associated with scenario #5.  Figure A.1.19 captures this concept by  illustrating the relative excess N by the various management scenarios.

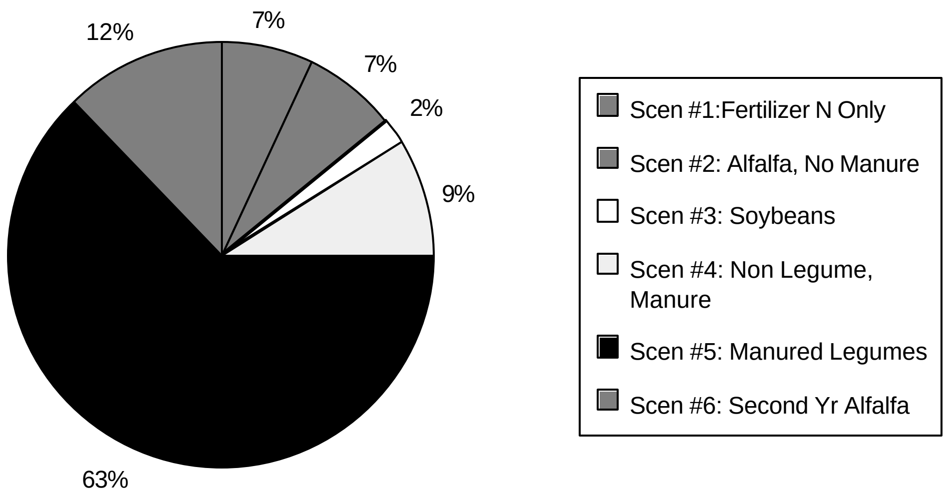


Figure A.1.19. Relative contributions of total excess N by the different management scenarios across all corn acres.

**Table A.1.8A.**
**Nitrogen Inputs and Balances Across All Southeast Areas**

| Scenario Number | Total Acres | PCN[1] (LBS/A) | PNC Total | Manure N (LBS/A) | Manure Total | Fert N (LBS/A) | Fert N Total | N Rec. [2] (LBS/A) | N Rec. Total | Excess (LBS/A) | Excess Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| 1 | 1,779 | 0 | 0 | 0 | 0 | 122 | 21,089 | 127 | 226,302 | 17 | 30,016 |
| 2 | 592 | 100 | 59,200 | 0 | 0 | 73 | 43,277 | 26 | 15,120 | 51 | 30,433 |
| 3 | 332 | 30 | 9,960 | 0 | 0 | 119 | 39,615 | 98 | 32,644 | 25 | 8,145 |
| 4 | 919 | 0 | 0 | 72 | 65,977 | 77 | 70,723 | 132 | 121,724 | 41 | 37,764 |
| 5 | 3,310 | 70 | 230,260 | 80 | 266,417 | 50 | 166,457 | 55 | 181,743 | 81 | 266,883 |
| 6 | 1,060 | 50 | 53,000 | 0 | 0 | 104 | 109,870 | 67 | 71,476 | 48 | 51,198 |
| | | | | | | | | | | | |
| **TOTALS FOR ALL SCENARIOS** | **7,992** | **44** | **352,420** | **42** | **332,393** | **81** | **647,031** | **81** | **649,000** | **53** | **424,438** |

**Table A.1.8B.**
**Nitrogen Inputs and Balances Across Excess**
**Nitrogen - Southeast Areas**

| Scenario Number | Total Acres | PCN[1] (LBS/A) | PNC Total | Manure N (LBS/A) | Manure Total | Fert N (LBS/A) | Fert Total | N Rec. [2] (LBS/A) | N Rec. Total | Excess (LBS/A) | Excess Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| 1 | 1,195 | 0 | 0 | 0 | 0 | 145 | 172,839 | 113 | 134,499 | 33 | 39,536 |
| 2 | 496 | 100 | 49,600 | 0 | 0 | 88 | 43,624 | 27 | 13,339 | 61 | 30,172 |
| 3 | 270 | 30 | 8,100 | 0 | 0 | 125 | 33,856 | 98 | 26,333 | 28 | 7,534 |
| 4 | 602 | 0 | 0 | 84 | 50,641 | 111 | 67,098 | 132 | 79,233 | 66 | 39,804 |
| 5 | 2,631 | 74 | 193,786 | 84 | 220,966 | 60 | 157,171 | 49 | 129,210 | 95 | 250,019 |
| 6 | 869 | 50 | 43,450 | 0 | 0 | 134 | 116,711 | 66 | 57,366 | 68 | 59,335 |
| | | | | | | | | | | | |
| **TOTALS FOR ALL SCENARIOS** | **6,063** | **49** | **294,936** | **45** | **271,607** | **98** | **591,299** | **73** | **439,980** | **70** | **426,419** |

**Table A.1.8C.**
**Nitrogen Inputs and Balances Across Shortage**
**Nitrogen Acres - Southeast Areas**

| Scenario Number | Total Acres | PCN[1] (LBS/A) | PCN Total | Manure N (LBS/A) | Manure Total | Fert N (LBS/A) | Fert Total | N Rec. [2] (LBS/A) | N Rec. Total | Shortage (LBS/A) | Shortage Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| 1 | 581 | 0 | 0 | 0 | 0 | 85 | 49,504 | 138 | 80,253 | 53 | 30,543 |
| 2 | 96 | 100 | 9,600 | 0 | 0 | 11 | 1,052 | 25 | 2,426 | 14 | 1,374 |
| 3 | 62 | 30 | 1,860 | 0 | 0 | 124 | 7,661 | 135 | 8,370 | 11 | 693 |
| 4 | 317 | 0 | 0 | 62 | 19,502 | 19 | 5,973 | 137 | 43,443 | 57 | 17,928 |
| 5 | 679 | 53 | 35,796 | 56 | 38,171 | 12 | 8,106 | 90 | 60,977 | 21 | 14,476 |
| 6 | 191 | 50 | 9,550 | 0 | 0 | 20 | 3,785 | 71 | 13,478 | 50 | 9,626 |
| | | | | | | | | | | | |
| **TOTALS FOR ALL SCENARIOS** | **1,926** | **29** | **56,806** | **30** | **57,673** | **40** | **76,081** | **108** | **208,947** | **39** | **74,640** |

[1] PNC = Previous Crop Nitrogen credit.
[2] Recommendations based on yield goal, previous crop and the organic matter according to the University of Minnesota recommendations where soil nutrient test results were not available.

**Scenario Definitions:**

**Scenario 1 = Acres receiving only fertilizer N; no PCN or manure applied.**
**Scenario 2 = Acres previously in alfalfa; no manure applied.**
**Scenario 3 = Acres previously in soybeans; no manure applied.**
**Scenario 4 = Acres receiving manure with no previous PCN.**
**Scenario 5 = Acres receiving manure with PCN.**
**Scenario 6 = Acres previously in alfalfa in 1991.**

# Conclusions and Summary of the Current Nutrient Management Practices in Southeast Minnesota

Sixty-three farms, covering over 25,000 acres, participated in the **FA**rm **N**utrient **M**anagement **A**ssessment **P**rogram (**FANMAP**) with staff from the Minnesota Department of Agriculture. Producers volunteered 2-4 hours of their time to share information about their farming operation. Producers were carefully selected to represent a wide diversity of management skills and farm characteristics. The overall purpose of the program was to develop a clear understanding of current farm practices regarding agricultural nutrients and utilize this knowledge for future water quality educational programs.

Nitrogen management in this region of the state is challenging due to its karst topography, significant alfalfa acres, and high dairy density. Manure management is also confounded by the popularity of daily scrape and haul collection systems. Approximately 20% of the manure-N available for land application results from this type of system. This area has a high diversity of storage/collection systems, most of which provide some opportunity for storage. The process of manure crediting is greatly simplified with manure storage systems that allow for a minimal number of land application events. Approximately 75% of the N retained after storage originated from a variety of systems that allowed for some storage benefits.

Proper timing of N applications is one of the key management strategies that producers in this region can implement to minimize N leaching losses. In the last 5 years, producers have been encouraged to avoid fall application. FANMAP determined that fall application of N was extremely rare; spring preplant and starter N accounted for 90% of applied N fertilizer. Source selection of N fertilizers were also in excellent agreement with current BMPs developed by MES in conjunction with MDA. Over 90% of the N fertilizers were ammonium based products.

The overall N rate attributed from all three sources (fertilizers, legumes and manure) is a critical issue. Manure accounts for approximately 25% of the 'first year available' N; legumes account for another 25%. Obviously proper crediting of both of these sources is needed to successfully manage N in southeast Minnesota. On corn acres where no previous manure or legume credits existed to confound the rate selection process, producers appear to be in excellent agreement with recommendations that were made by UM/MES **four to five years ago**. Consequently due to the development of more conservative recommendations, producers were over-applying fertilizer inputs by 17 lb/N/A. Roughly 70% of the acreage in this particular scenario received N rates in excess of UM recommendations. Interestingly, the remaining 30% were significantly under-fertilized (-53 lb/A).

Overall, producers reduced N fertilizer inputs following "first year" alfalfa. However, additional reductions (50 lb/A) could be made with a low probability of yield loss. Producers also reduced N fertilizer inputs by approximately 20 lb/A for second year alfalfa; additional credits of 47 lb/A could be obtained by following research based BMPs. It appears that producers need the assessment tools for determining alfalfa stand densities and record keeping systems to aid in more effectively capturing alfalfa credits. Soybean crediting was almost non-existent, however, this crop occupied only 5% of the total cropland of the farms participating in the study.

Producers were basically reducing commercial N inputs by 45 lb/A in scenarios where previous manure applications were made to non-legume crops such as corn. Producers were under-estimating the value of the manure by approximately 40 lb/A. In southeast MN, it is a very common practice to apply manure to old alfalfa stands which are followed by corn in the rotation. In this scenario, producers were found to reduce their commercial inputs by approximately 70 lb/A. However the combination of alfalfa and manure credits, coupled with the fertilizer (average of 50 lb/A), resulted in over-applications of 80 lb/A. In these situations, only a starter N application should be applied and would trim 30 to 35 lb/N/A from the N budget. Producers could capture a much higher percentage of the "fertilizer replacement value" by applying the manure into other corn rotations. Although 85% of the "first year" available N was applied to corn in this study, only 50% of the corn acres received annual applications of manure. From a water quality perspective, the most significant impacts could be made by improving the N crediting process in this particular cropping scenario.

In previously studies by the MN Extension Service, the nutrient value from manure has been found to be highly variable. Results from the 46 samples analyzed as part of this program were no exception. Manure testing needs continual promotion as a fundamental part of a nutrient management plan. Only 15% of the producers had tested their manure previously to this project.

There were some very positive findings from this study. There is strong evidence that producers are voluntarily adopting the educational materials and strategies developed by the University of Minnesota/MN Extension Service. It is also evident that promotional activities need to continue and be specifically targeted to deliver the most recent technology and recommendations.