A. Status:

General Information: Farms on Non-Irrigated Outwash Soils

County Educators (MN Extension Service) from Becker, Hubbard, Otter Tail, Todd, and Wadena counties were contacted and individually interviewed in October,1994. Purpose of the interviews was: to inform them of the specifics of the project and overall goals; obtain pertinent county information (i.e. locations of outwash sands); 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. Part of the criteria for consideration was that the farms needed to be overlying outwash sands and that they were dominantly non-irrigated. Fifteen to twenty contacts, classified as either "Low", "Average" , or "High" management skills, were collected in each of the five counties. Introduction letters (Appendix A-1), signed by the Commissioner of Agriculture, were mailed out to the farmers in November, 1994. 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. A total of 76 letters were send and 58 (76%) producers went through the interview process.

Nutrient Management Data Collection: Farms on Non-Irrigated Outwash Soils

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 789 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 1994 cropping season. Crop types and manure applications (starting in the fall of 1993) were also collected from the 1993 season for purposes of 1994 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.

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[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: Farms on Non-Irrigated Outwash Soils

Fifty-eight (58) farmers were interviewed during December, 1994 and January, 1995. Total inventoried acres by county (and number of farms per county) are as follows: Becker 4,235 (9); Hubbard 6,545 (13); Otter Tail 9,169 (13); Todd 5,729 (11); and Wadena 6,057 acres (12). Total area covered by the interviews was 31,735 acres; 18,902 acres were identified as tillable (Table A.1.-1). The average farm size was 541 acres with 320 acres in cropland. Thirty-two (32) of the farms were dominantly dairy. All the remaining farms had some type of livestock although the animal types were highly variable.

Table A.1.-1. General description of all farms participating in the 1994 Non-Irrigated Central Sands nutrient management survey.

		Total Acreage Inventoried			Average Acreage by Farm		
County	Farm	Total(1)	Crop(2)	Noncrop	Total(1)	Crop(2)	Noncrop
		.... Number of Acres			....		
Becker	9	4,235	2,377	1,858	470	264	206
Hubbard	13	6,545	3,261	3,284	504	251	253
Otter Tail	13	9,169	6,477	2,692	705	498	207
Todd	11	5,729	3,139	2,590	521	285	235
Wadena	12	6,057	3,648	2,409	505	304	201
Mean	**11.6**	**6,347**	**3,780**	**2,567**	**541**	**320**	**220**
Total	**58**	**31,735**	**18,902**	**12,833**	**2,705**	**1,602**	**1,102**
Percent Total		**100**	**59.6**	**40.4**			

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

Corn (31%), hay[2] (29%) and small grains (16%) accounted for over 76% of the cropland acres (Figure A.1.-1). Remaining acres were highly mixed. In contrast, the cropland distribution across <u>all farms in the five county area</u>[3] was dominated by corn (26%), hay (29%), soybeans (11%) and small grains (29%) (Figure A.1.-2). The selected farms were skewed towards more miscellaneous crops and less soybean and grain acres than the overall five county distribution. County specific data is given in Table A.1.-2.

[2] Defined as the sum of alfalfa and clover acreage.

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

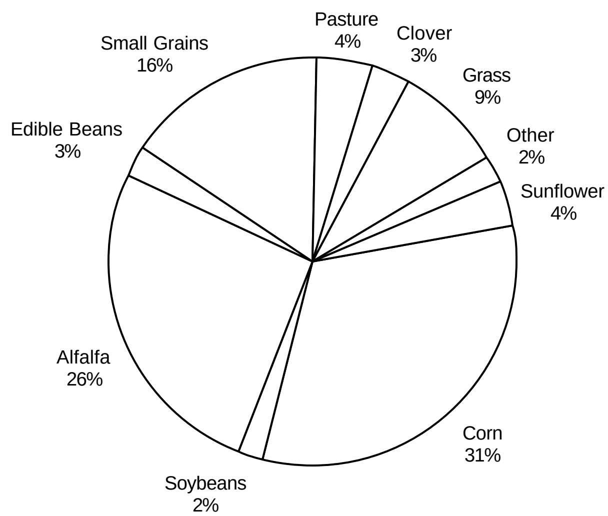

Figure A.1.-1. Crop type distribution across all cropland acres of the selected farms.

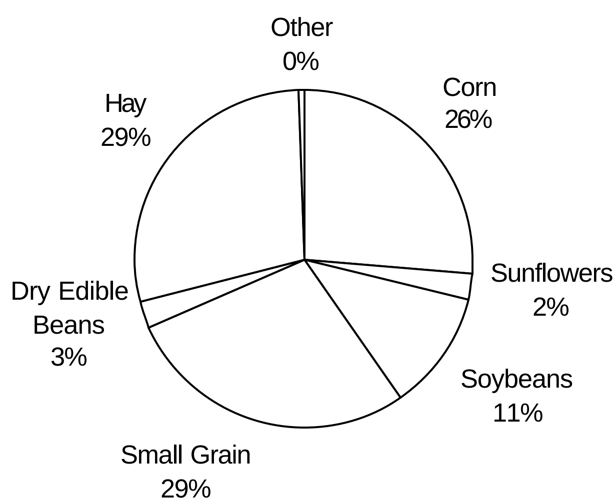

Figure A.1.-2: Crop type distribution across **all** cropland acres in Becker, Hubbard, Otter Tail, Todd, and Wadena Counties. Acreage based on 1993 statistics (MN Agricultural Statistics, 1994)

Table A.1.-2. Average distribution of cropland acres per farm by county - 1994								
County	**Corn**	**Alfalfa**	**Small Grains**	**Edible Beans**	**Sun-flower**	**Clover**	**Other**	**Total**
	In Acres							
Becker	289	870	683	0	201	20	314	2377
Hubbard	600	761	547	265	208	10	870	3261
Otter Tail	2826	1462	1215	246	270	216	242	6477
Todd	1307	832	252	0	0	271	477	3139
Wadena	1005	1009	287	0	0	20	1327	3648
Mean	**1205**	**987**	597	102	136	**107**	**646**	**3780**
Total	**6027**	**4934**	**2984**	**511**	**840**	**1671**	**3230**	**18902**
Total By Percent	**31.9**	**26.1**	**15.8**	**2.7**	**3.6**	**2.8**	**17.1**	**100.0**

Commercial Fertilizer Use Characteristics on Selected Farms: Farms on Non-Irrigated Outwash Soils

Corn (61%) and small grains (20%) accounted for 81% of the total N commercial fertilizer use (Figure 3). Ninety-three percent (93%) of the total corn acreage and 68% of the small grains received commercial N fertilizer (Table A.1.-3). Average fertilizer N rate on corn acres was 53 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 edible beans received 20, 50, and 70 lb/N/A, respectively (Table A.1.-3 and Figure A.1.-4). Phosphate rates ranged between 17 to 25 lb/A across the major crops (Table A.1.-3).

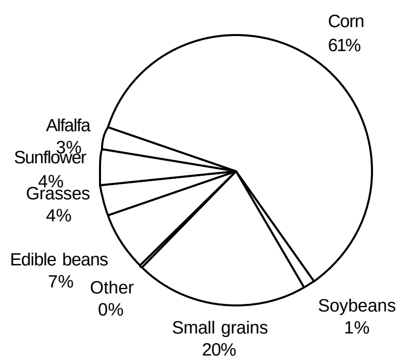

Figure A.1.-3. Distribution of commercial nitrogen fertilizer by crop type. Total nitrogen supplied by fertilizer was 496,000 pounds across all 58 farms.

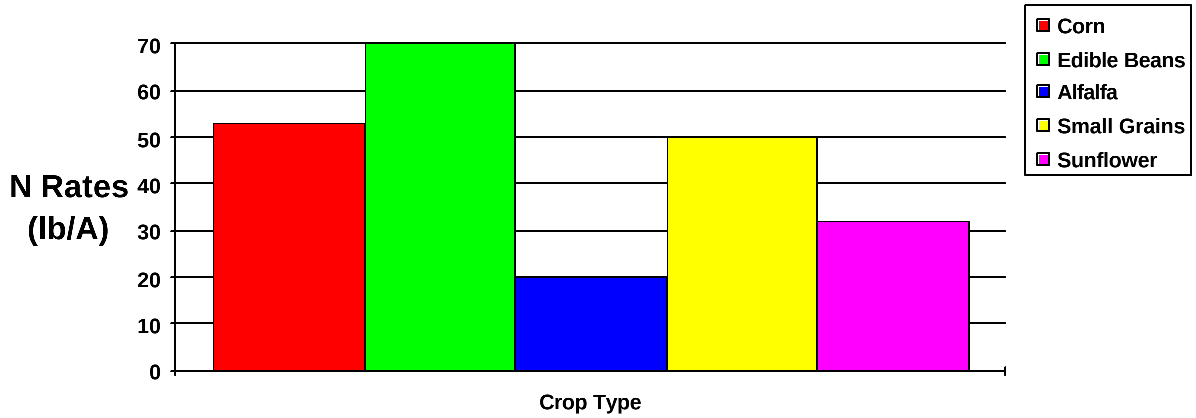

Figure A.1.-4. Average N fertilizer rates across fertilized acres by crop type.

Table A.1.-3. Distribution of commercial nitrogen and phosphate applications on cropland - 1994

Crop	Acres Receiving N Fertilizer	Total N Applied (LBS X 1000)	Acres Receiving Phosphate Fertilizer	Total Applied P_2O_5 (LBS X 1000)
Corn	5,621	298.1	5,263	92.2
Clover	16	0.8	16	0.1
Soybeans	158	6.9	0	0
Alfalfa	700	13.9	574	14.4
Small Grains	2,016	101.4	1,520	26.5
Edible Beans	511	35.6	246	4.3
Sunflower	626	20.3	596	12.4
Other	335	18.9	0	0.0
TOTALS	**9,985**	**496**	**8,215**	**150**

Timing of N fertilizer applications is an important consideration in maximizing fertilizer use efficiency and minimizing environmental effects. Due to the high probability of leaching in these coarse-textured soils, the overall strategy is to apply the N to closely match crop uptake. Best Management Practices (BMPs)[4] developed for this region of Minnesota focus on a number of timing issues. First, fall applied N is not recommended under any circumstances. In this study, there was no fall fertilization on corn (Figure A.1.-5) and less than 2% of all remaining N fertilizers used on non-corn crops was fall applied (Figure A.1.-6).

[4] M.A. Schmitt and G.W. Randall 1993. Best Management Practices for Nitrogen Use in East-Central and Central MN. . AG-FO-6129-B.

Secondly, "when soils have a high leaching potential, application of nitrogen is a sidedress or split application program is preferred"[5]. In this study, over half of the N is applied prior to corn emergence (Figure A.1.-5). Considering the low total rate of application (53 lb/A) and that recommended starter N rates are usually 10-20 lb/A, this distribution appears consistent with existing BMPs. The same conclusions are the same for all "non-corn" applications (Figure A.1.-6).

Another important BMP is to select the proper N source. In situations were the bulk of the N is applied in a single application, anhydrous ammonia or urea are highly recommended. These two forms of N account for only 19% of the total commercial use (Figure A.1.-7). Granulars[6] accounted for 81% of the applied commercial N. A high percentage of the granulars are ammonium based; negative environmental impacts from these types of products are probably minimal. Amounts of nitrate based products such as ammonium nitrate or UAN were very limited. The N source selections found in this study are vastly different than the results from irrigated agriculture in the same counties[7]. Generally anhydrous ammonia and urea account for 60-70% of the total N sales.

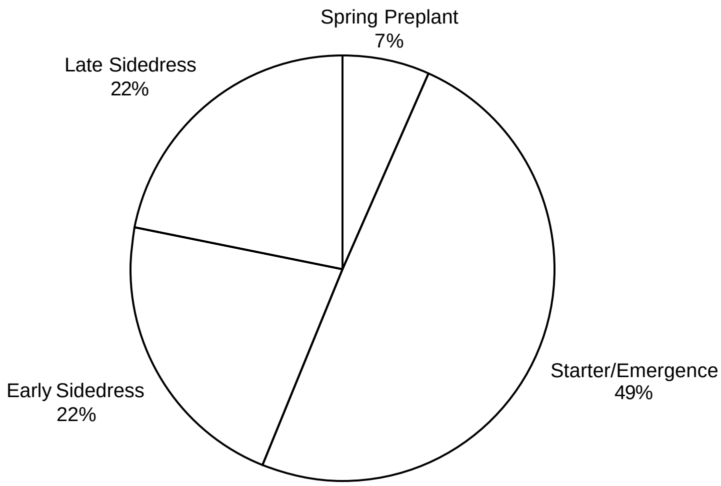

Figure A.1.-5. Timing of N fertilizer applications on corn acres. Overall mean N rate was 53 lb/A.

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[5] M.A. Schmitt and G.W. Randall 1993. Best Management Practices for Nitrogen Use in East-Central and Central MN. . AG-FO-6129-B.

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

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

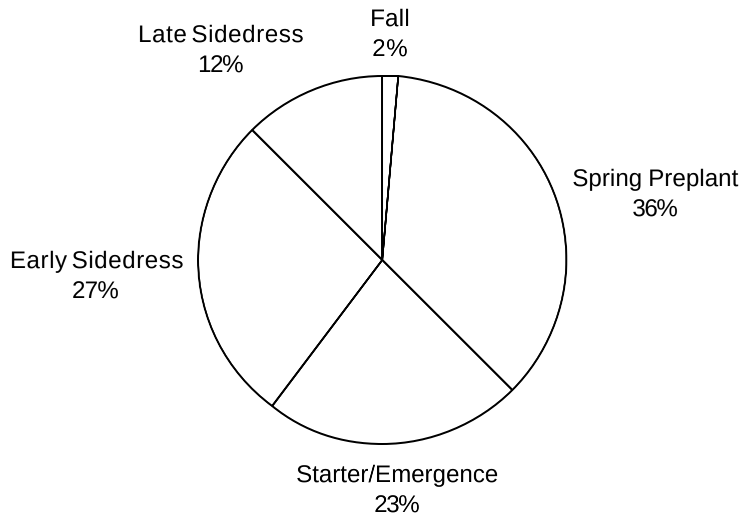

Figure A.1.-6. Timing of N fertilizer applications on all "non corn" acres. The overall mean N rate was 45 lb/A. Over half of the N on "non corn" acres was applied to small grains.

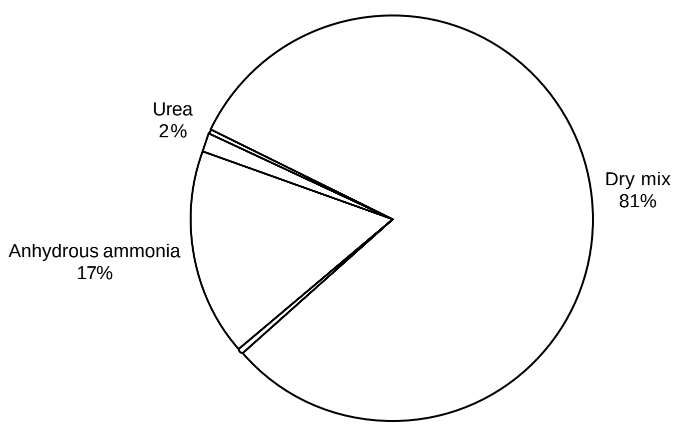

Figure A.1.-7. Contributions of N from various fertilizer sources on selected farms.

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. Inhibitor use is recommended on coarse-textured soils with early spring applications. Due to the low N rates used on these farms, the use of inhibitors would be cost prohibitive. Only one producer used an inhibitor on 120 acres of corn.

Livestock and Manure Characteristics of the Selected Farms: Farms on Non-Irrigated Outwash Soils

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. As previously mentioned, over half the farms were dairy and the remaining were a wide mix of animal types as indicated by Table A.1.-4. This table includes a complete animal inventory, including nitrogen and P_2O_5 produced[8] and collected.

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	2,029	427.0	387.2	173.0	156.9
Calves & Heifers	2,143	210.8	132.8	84.5	53.0
Dairy Steers	331	45.8	38.8	18.6	15.8
Boars	32	1.0	0.9	0.8	0.7
Sows & Litters	638	18.8	18.8	14.7	14.7
Feeders (20 - 50 pounds)	10,163	1.0	1.0	0.3	0.3
Finishers (50 -240 pounds)	8,387	33.6	33.6	12.6	12.6
Bulls	64	11.9	2.8	8.8	2.0
Beef Cows & Calves *	1,369	211.8	59.5	161.0	45.2
Beef Feeders	237	38.2	22.0	27.6	15.9
Sheep Ewes	699	11.2	5.6	3.8	1.9
Feeder Lambs	1,125	9.0	3.8	3.2	1.3
Chickens	900	0.1	0.0	0.1	0.0
Turkeys	175,000	191.3	191.3	169.2	169.2
Horses	18	1.4	0.7	0.5	0.2
TOTAL		**1,213**	**899**	**679**	**490**

Estimated amounts of N and P_2O_5 **per farm** produced from all livestock were 21,000 and 12,000 pounds, respectively . Dairy cows, calves and heifers generated approximately half of the associated N (Figure 8) and P_2O_5 (Figure A.1.-9) produced through manure .

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

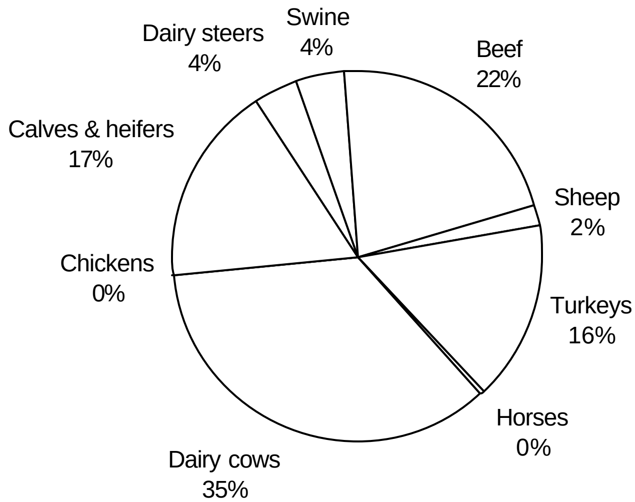

Figure A.1.-7. Amounts of nitrogen (total) generated by animal types across all selected farms. Total N produced was 21,000 pounds/farm.

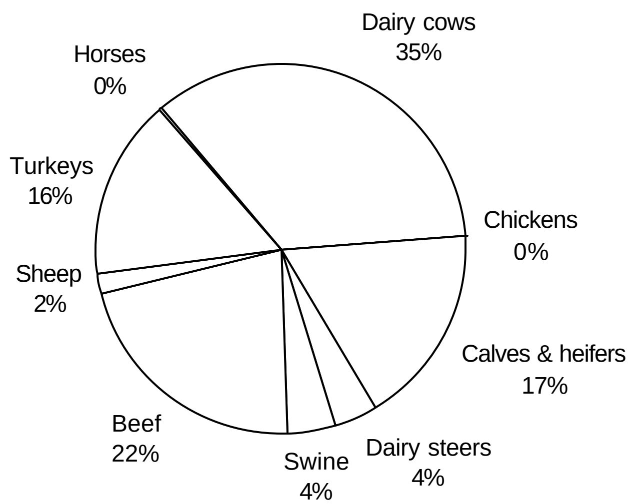

Figure A.1.-9. Amounts of P_2O_5 generated by animal types across all selected farms. Total P_2O_5 produced was 12,000 pounds/farm.

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. Types of manure collection systems of the 58 farms can be best catagorized as; liquid systems (28); lots/barns/pasture (26) and daily haul (4).

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 11), the dominant collection systems on the Central Sands are; animal barns (47%), earthen pits (27%) and pits under barns (16%). It appears that producers have the equipment facilities to store roughly three-fourths of the manure (based on retained N) and should not be subjected to applying manure during poor weather conditions. Daily scrape and haul systems pose difficult environmental challenges and field-applied losses after are high if not properly incorporated. The importance of this type of system, based on nutrients generated, is rather small.

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	59.4	14.9	44.5	26.2	0	26.2
Unpaved Lot	54.2	27	27.2	39.9	11.94	28.0
Paved Lot	8	4	4.0	5.6	1.7	3.9
Animal Barn	427.3	128.1	299.2	276.5	0	276.5
Paved Pad	8.8	1.9	6.9	3.6	0	3.6
Pit Under Barn	76.7	16.9	59.8	38.9	0	38.9
Slurrystore	9.4	2.1	7.3	3.8	0	3.8
Earthen Pit	238.8	71.8	167.0	100.0	0	100.0
Above Ground Tank	14.5	3.2	11.3	7.6	0	7.6
Poultry Pit	2.3	1.9	0.4	0.9	0	0.9
Compost	0.4	0.0	0.4	0.3	0	0.3

SUBTOTAL	899.8	271.8	628.0	503.3	13.6	489.7

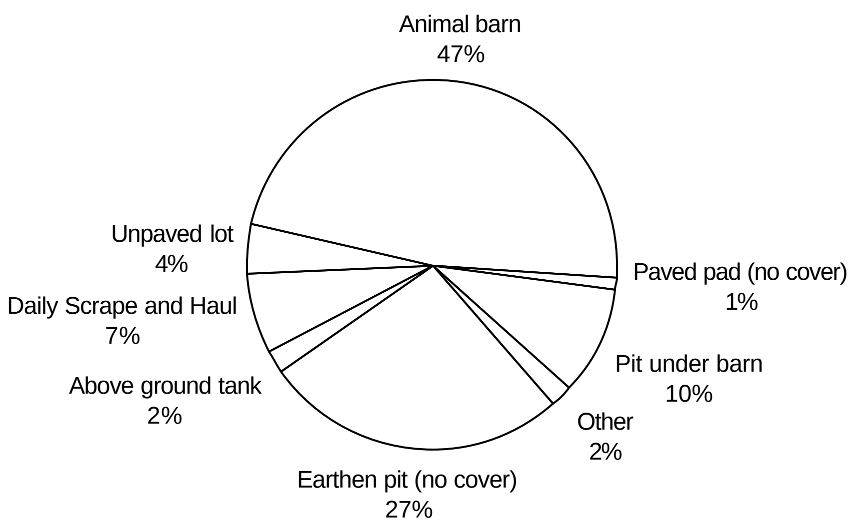

Figure A.1.-10. Contributions of total **nitrogen retained after storage** by manure collection systems.

Nutrient losses from collection and storage were estimated from accepted guidelines[9] 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 316,000 lb of "first year available" N. This represents 5,500 lb/N/farm.

The fate of manure-N has been summarized in a simple flow diagram (Figure A.1.-11). This diagram simplifies the complexities associated with N from excretion to "plant available". Over half of the "first year available" N (on a weight basis) was applied to corn (Figure A.1.-12). Alfalfa (15%) and small grains (14%) received the bulk of the difference.

Manure testing is a critical component in nutrient management planning. Approximately 10% 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. Samples are currently being collected and analyzed.

[9] 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	NH_4^+ (Inorganic)	Organic N	Mineralized Organic N 1st Yr. Avail	Application Losses	Timing Losses	Manure-N First Yr. Available
	Pounds Manure Nitrogen X 1000						
Corn	311.9	166.1	145.8	46.5	29.7	13.7	169.2
Clover	15.5	8.6	7.0	2.3	1.5	0.9	8.5
Alfalfa	88.8	48.3	40.5	14.0	9.9	3.9	48.5
Small Grains	81.9	44.7	37.2	12.1	8.9	3.1	44.7
EdibleBeans	22.0	13.2	8.7	2.6	3.0	0.9	12.0
Pasture	18.7	11.2	7.6	2.9	4.1	0.8	9.2
Grasses	18.5	10.2	8.3	2.8	3.3	1.0	8.7
Sunflower	11.3	6.7	4.6	1.4	0.8	0.2	7.2
Other	12.4	6.9	5.6	2.0	0.5	0.5	7.8
TOTAL	**581**	**316**	**265**	**87**	**62**	**25**	**316**

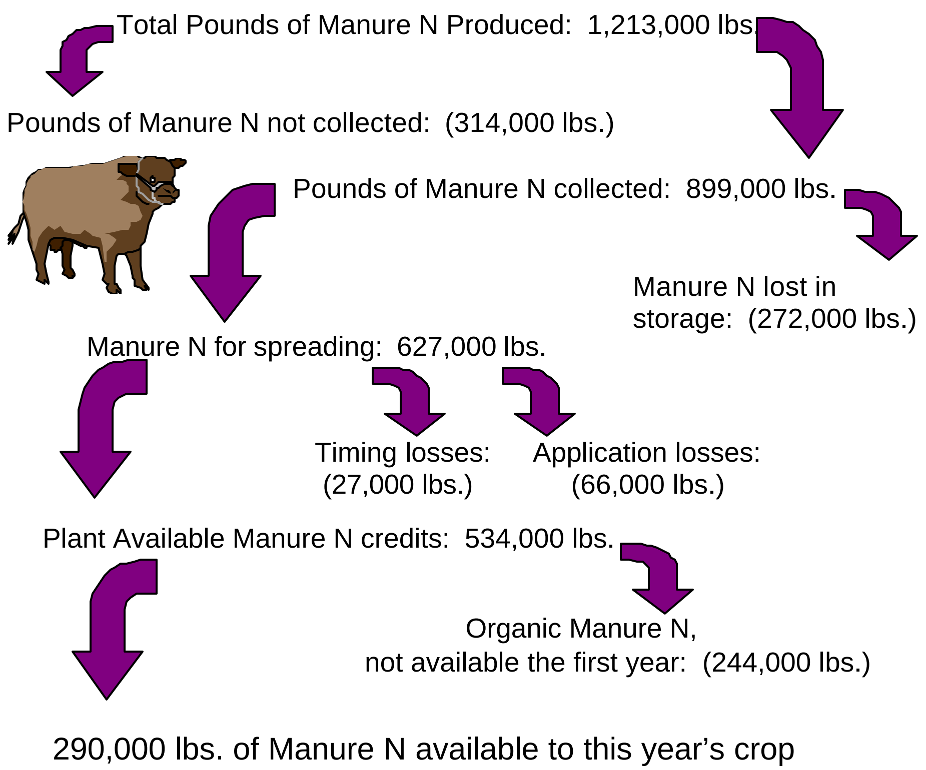

Figure A.1.-11. Fate of manure-N across all storage and management factors.

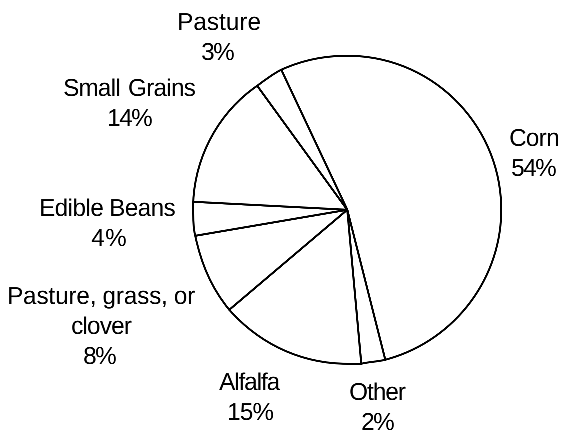

Figure A.1.-12. Distribution of "first year available" nitrogen by crop type calculated on a weight basis.

Relative Importance of N and P Sources on the Selected Farms: Farms on Non-Irrigated Outwash Soils

Commercial fertilizer (55%), manure (35%), and legume[10] (10%) contributed a total of 903,000 pounds of "first year available" N across all farms. Commercial fertilizer (23%) and manure (77%) contributed a total of 640,000 pounds of P_2O_5.

Commercial fertilizer (50%), manure (33%), and legume (17%) contributed a total of 525,000 pounds of "first year available N" to **corn acres** (Figure A.1.-13). This is an average N rate of 90 lb/A across all corn acres. The percent contributions from organic sources (accounting for a total of 50% of the inputs) is considerably higher than many other regions across state. These percentages are similar to southeast MN[11], however the total N inputs are considerably less on these outwash sands. The average N input in southeast MN was 167 lb/A. Proper crediting for these sources is critical in maintaining economic and environmental balances.

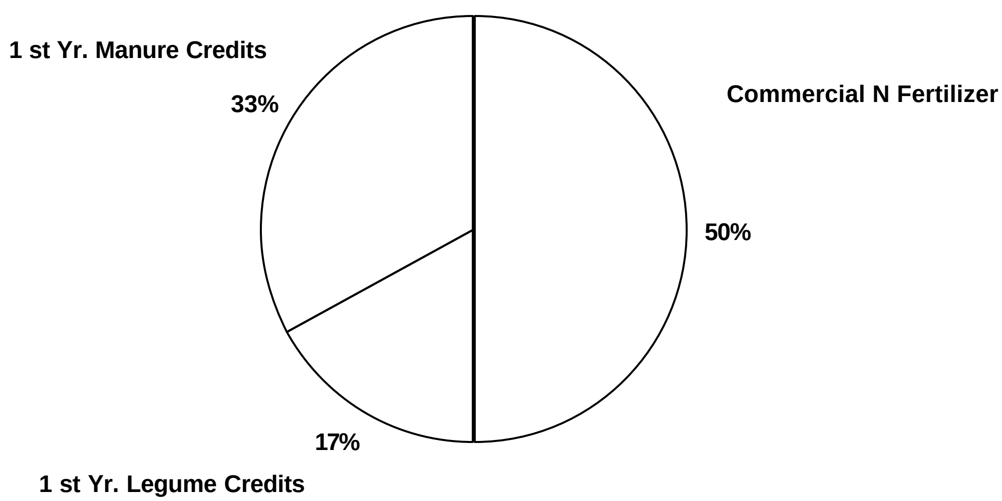

Figure A.1.-13. Relative contributions from fertilizers, manures and legumes on first year available N across all corn acres. Average N input across all corn acres 90 lb/A.

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

[11] Effective Manure Management in Conservation Tillage Systems for Karst Areas, LCMR 1993-95.

Nitrogen Balances and Economic Considerations: Farms on Non-Irrigated Outwash Soils

The corn yield goal across all five counties was 70 bushels/A. Current University of Minnesota N recommendations to fulfill this goal is 60 lb/N/A (Figure A.1.-14). Factoring in all appropriate credits from fertilizer, legumes and manures, there was an over-application rate of 26 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 (1993[12]) 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. Statewide[13] recommended N credit for previous soybean crop is now 40 lb/A. However, UM recommendations also suggest reducing the credits to 20 lb/A on coarse-textured soils with low yield potential. We inadvertently used a 30 pound credit. Since the amount of acres in beans is minimal in this sample population, the error is probably insufficient. Based only on the N fertilizer replacement value, proper crediting could save these producers approximately $5/A[14] assuming no additional transportation and labor costs.

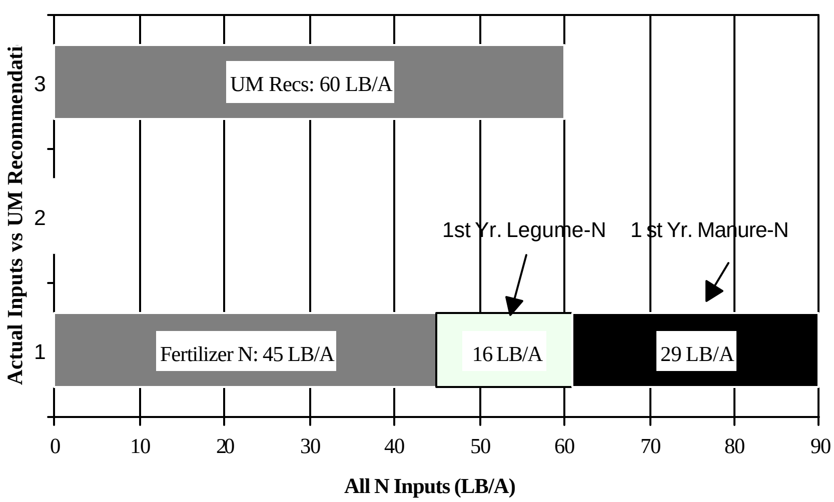

Figure A.1.-14. Crop N requirements based on University of MN recommendations in comparison to actual N inputs (fertilizer, legumes, and manure) across all corn acres. Total corn area in this analysis was 5,821 acres.

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[12] Referring to any manure applications prior to those made in the fall of 1993.

[13] G. Rehm, M. Schmitt, and R. Munter. Fertilizer Recommendations for Agronomic Crops in Minnesota. 1994. BU-6240-E.

[14] Based on a nitrogen fertilizer price of $0.20/pound.

Balances were examined in more detail by lumping the **1994 corn acreage** into six different scenarios:

Scenario 1: N from fertilizer only; no manure or legume credits;
Scenario 2: Previously alfalfa (1993); no manure applied;
Scenario 3: Previously soybeans (1993); no manure applied;
Scenario 4: Previously a non-legume crop, manure applied;
Scenario 5: Previously a legume crop (1993), manure applied;
Scenario 6: Previously alfalfa (1992).

Nitrogen balances for all corn acres are broken down into these scenarios in Table 8. Fertilizer N rates specific to each scenario is illustrated in Figure 15. The commercial N rates in scenario 1 (no legumes, no manure) averaged 58 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:**

* Scenario #2: Producers reduced N fertilizer by 17 lb/A for the "first year" alfalfa credits (N rate averaged 41 lb/A);

* Scenario #3: Soybean acres were limited and no comparison were possible;

* Scenario #4 and #5: Producers also 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 24 lb/A and 17 lb/A, respectively. These translate into reduction of 41 and 29%, respectively, in comparison to acres receiving only commercial N.

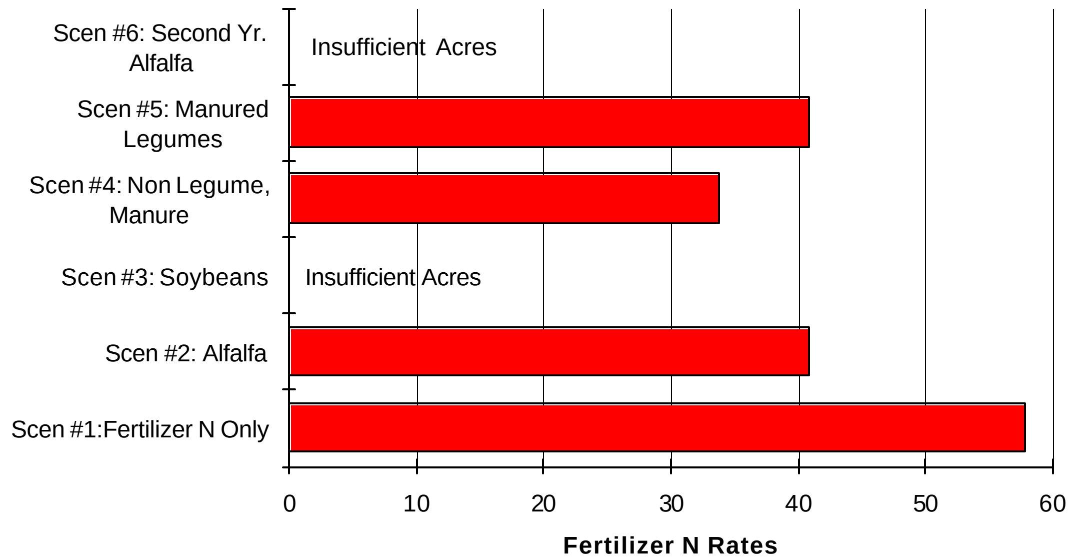

Figure A.1.-15. Commercial fertilizer N rates on corn by management scenario. See definitions for complete description of rotation and land application details.

Factoring in legume and manure credits into the process on a field-by-field basis, the amounts in excess 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.

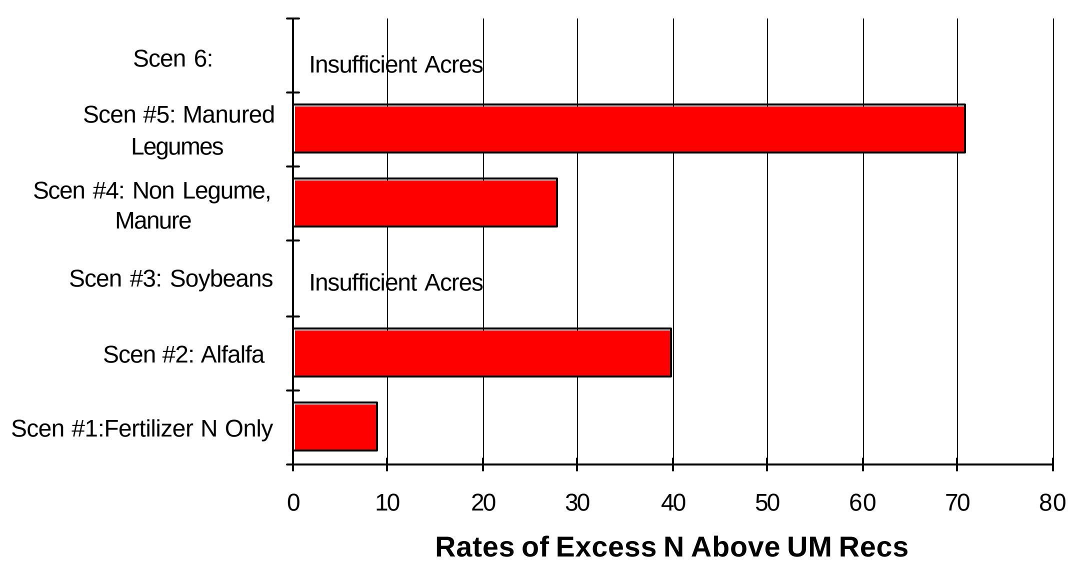

Figure A.1.-18. Amounts of N in excess of 1994 University of Minnesota recommendations across the different management scenarios. Analysis includes all 5,821 acres of corn.

Producers were making minor over-applications in scenario 1. Over-application rates in scenarios 2 and 4 ranged from 28-40 lb/A, respectively. Clearly the scenario where producers most severely over-applied N was on previous legume crops which received manure applications (scenario 5) prior to corn production.

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. Fifty-four (54%) of the total corn acres were classified into the ABOVE category. Excess amounts of N averaged 42 lb/Acre. The remaining acres (46%) were classified as BELOW UM recommendations. Shortage amounts of N average 23 lb/A and it is interesting to note that most of this shortage fell into scenario 1 (commercial N only).

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 #4 (42% of the total) and #5 (35%). Figure A.1.-17 captures this concept by illustrating the relative excess N by the various management scenarios.

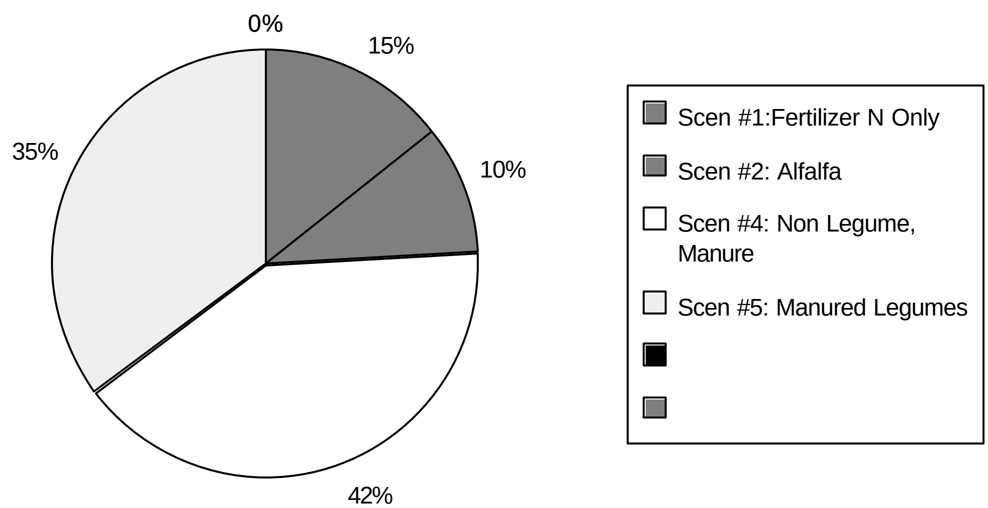

Figure A.1.-17. Relative contributions of total excess N by the different management scenarios across all corn acres.

Table A.1.-8A.
Nitrogen Inputs and Balances Across All Central Sands Non-Irrigated 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	2,399	0	0	0	0	58	138,801	69	165,793	9	21,891
2	360	100	36,000	0	0	41	14,627	1	330	40	14,297
3	24	30	720	0	0	40	960	60	1,440	0	0
4	2,165	0	0	59	128,227	34	73,231	72	156,192	28	60,662
5	733	64	46,931	58	42,231	41	29,858	27	19,822	71	52,306
6	140	52	7,240	0	0	42	5,915	29	4,006	21	2,980
TOTALS FOR ALL SCENARIOS	**5,821**	**16**	**90,891**	**29**	**170,458**	**45**	**263,392**	**60**	**347,583**	**26**	**152,136**

Table A.1.-8B.
Nitrogen Inputs and Balances-Excess Nitrogen-Across
All Central Sands Non-Irrigated 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	917	0	0	0	0	93	85,626	71	65,488	22	20,322
2	180	100	18,000	0	0	57	10,249	1	166	56	10,140
3											
4	1,218	0	0	70	85,356	40	49,297	69	83,892	42	51,139
5	715	60	42,723	51	36,368	49	35,373	38	26,932	63	44,876
6	59	54	3,190	0	0	64	3,756	16	950	47	2,797
TOTALS FOR ALL SCENARIOS	**3,089**	**21**	**63,913**	**39**	**121,724**	**60**	**184,301**	**57**	**177,428**	**42**	**129,273**

Table A.1.-8C.
Nitrogen Inputs and Balances Across Shortage
Nitrogen Acres - All Central Sands Non-Irrigated 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	1,482	0	0	0	0	39	58,533	68	100,573	28	41,166
2											
3	24	30	720	0	0	40	960	60	1,440	0	0
4	947	0	0	41	38,357	22	21,108	80	75,796	17	15,901
5	18	30	540	21	378	30	540	60	1,080	9	158
6	42	50	2,100	0	0	14	606	40	1,680	25	1,070
TOTALS FOR ALL SCENARIOS	**2,513**	**1**	**3,360**	**15**	**38,915**	**33**	**81,747**	**72**	**180,569**	**23**	**58,296**

[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 on Non-Irrigated Central Sands

Fifty-eight farms, covering over 31,000 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 on the Central Sands is challenging due to the nature of the soils and additional management skills required to manage organic N inputs. Manure accounts for approximately 33% of the 'first year available' N; legumes account for another 17%. Obviously proper crediting of both of these sources is needed to successfully manage N on these outwash sands. Yield goals varied tremendously on these outwash soils due to the wide range of organic matter content and available moisture holding capacity. The overall corn yield goals were 70 bu/A. Consequently, the nutrient inputs in general were significantly lower than most other regions of the state.

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. Corn acres which were above or below the UM recommendations were equally distributed.

Overall, producers reduced N fertilizer inputs following "first year" alfalfa by 17 lb/A. However, additional reductions (20-30 lb/A) could be made with a low probability of yield loss. One of the difficulties in the data collection process was obtaining reliable alfalfa information prior to stand termination. 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.

Producers were basically reducing commercial N inputs by 24 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 25 lb/A. It is a 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 17 lb/A. However the combination of alfalfa and manure credits, coupled with the fertilizer (average of 40 lb/A), resulted in over-applications of 70 lb/A. In these situations, only a starter N application should be applied and would trim 20 to 30 lb/N/A from the N budget. Due to the low yield potentials of these soils, all the N requirements for corn will be supplied from alfalfa stands of 2 plants/ft or denser. Producers could capture a higher percentage of the "fertilizer replacement value" by applying the manure into other corn rotations. Approximately 50% of the corn acres did not receive any manure application so there is ample locations to apply the manure. From a water quality perspective, the most significant impacts could be made by improving the N crediting process in this particular cropping scenario.

Proper timing of N applications is one of the key management strategies that producers in this region can implement to minimize N leaching losses. Producers have been encouraged to avoid fall application on any coarse-textured soils. FANMAP determined that fall application of N was extremely rare; spring preplant and starter N accounted for 56% of applied N fertilizer with the remaining balance sidedressed. Timing and source selection of N fertilizers appeared to be in excellent agreement with current BMPs developed by MES in conjunction with MDA. A very high percentage of the N fertilizers were ammonium based products.

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. Over 80% of the N retained after storage originated from a variety of systems that allowed for some storage benefits. In previously studies by the MN Extension Service, the nutrient value from manure has been found to be highly variable. Manure testing needs continual promotion as a fundamental part of a nutrient management plan. Only 10% 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. Strong similarities exist in all existing FANMAP projects: producers are generally managing commercial N inputs successfully (although frequently using outdated recommendations) but continually under-estimate the N credits associated with manure and alfalfa inputs.