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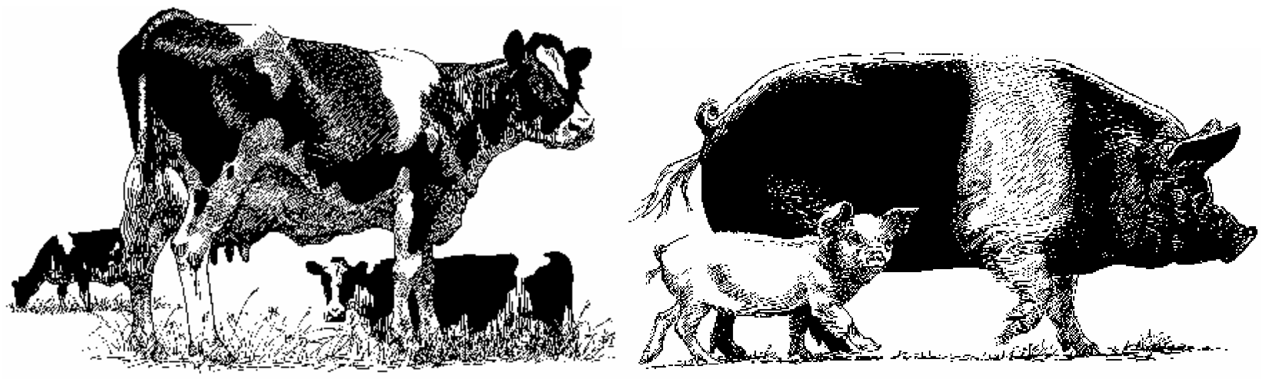
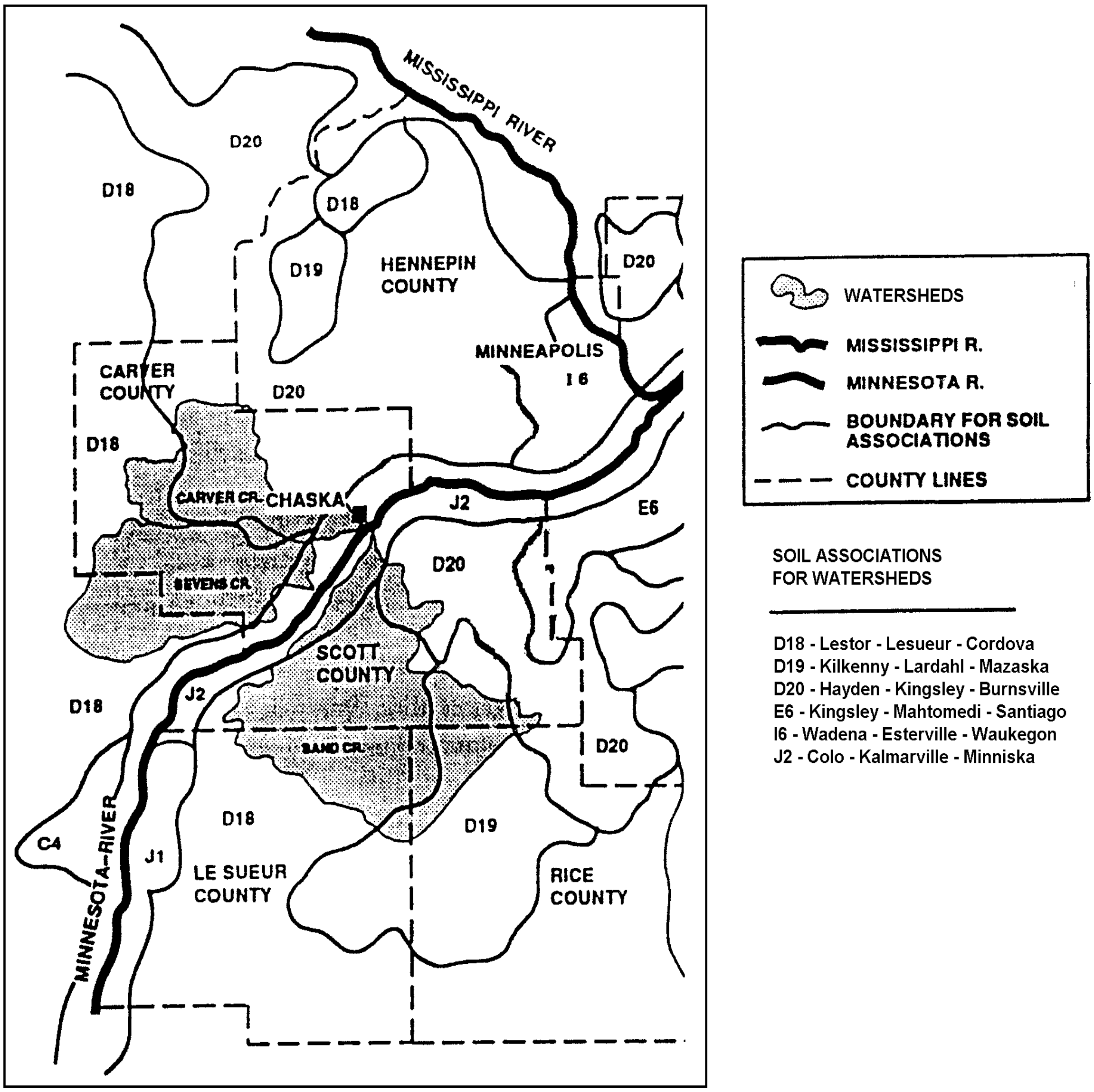
Survey of 28 Farms in the Bevens Creek Watershed and Sand Creek Watershed



General Information: Farmers in Bevens and Sand Creeks watersheds

Water quality of the Lower Minnesota River is of significant concern to both people who live within the watershed and those who enjoy the downstream recreational benefits of the river. Agricultural practices are a source of contamination and adoption of environmentally sound practices may reduce contamination of the river. Scott and Bevens Creeks[1] are two minor watersheds (located across the five counties of Carver, Scott, Le Sueur, Rice, and Sibley) that are part of the larger Minnesota River Watershed (Figure 1). Farmers were interviewed across these two watersheds to collect data on their existing farming practices that would effect the water quality of these watersheds.



[1] Carver Creek Watershed was paired with Bevens Creek Watershed during farmer interviews.

County Educators (MN Extension Service) from Carver, Scott, Rice, Sibley, and Le Sueur counties were contacted and individually interviewed in August, 1995. Purpose of the interviews was: to inform them of the specifics of the project and overall goals; obtain pertinent county information (i.e. locations and demographics of farmers in each specific watershed); 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 personal telephone calls to the potential participants after the introduction letter was mailed. Each district manager of the Soil and Water Conservation District was also contacted as well as each Natural Resources Conservation Service office (district conservationist). Each organization participated to provide a list of possible contacts. Sixty to seventy contacts, classified as either "Low", "Average" , or "High" management skills, were collected across all five counties. Introduction letters signed by the Commissioner of Agriculture, were mailed out to the farmers in September, 1995. The letter's intent was to identify: the overall 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 42 letters were sent and 28 (67%) producers went through the interview process.

The ability for agencies and the Extension Service to document producer adoption rates of various Best Management Practices is a critical component of the 1989 Groundwater Protection Act. The Minnesota Department of Agriculture has developed the **FA**rm **N**utrient **M**anagement **A**ssessment **P**rogram (**FANMAP**) to get a thorough understanding of current farm practices regarding agricultural inputs. This information will be used to design effective water quality educational programs and serve as baseline data to determine program effectiveness over time. In the past three years, over 300 farmers have volunteered 2 to 4 hours of their time to share information about their farming operations. This previous information was collected as a result of six individual studies funded through Legislative Commission on Minnesota Resources (LCMR) projects or Cleanwater Partnership Programs. This information will be collectively summarized into a statewide report later in 1996.

FANMAP techniques were also utilized in this study. Fourteen farmers were selected to represent the Bevens Creek watershed (Carver-10, Sibley-4) and fourteen farmers were selected to represent the Sand Creek watershed (Scott-9, Le Sueur-3, Rice-2). Farms were selected to proportionally represent each of the watersheds. Bevens and Sand Creeks watersheds occupy major portions of Carver and Scott Counties respectively. Bevens Creek extends out of Carver County and into a small portion of Sibley County. Sand Creek extends out of Scott County and into a small portion Le Sueur and of Rice Counties.

Nutrient Management Data Collection: Bevens and Sand Creeks Watersheds

Inventory forms and database design were patterned after a previous successful project[2]. Timing, rates, and method of applications were collected for all nitrogen (N), phosphate (P_2O_5), and potassium (K_2O) inputs (fertilizers, manures, and legumes) on **a field-by-field basis for all acres owned or rented**. Tillage equipment used and the number of passes on each field was also recorded. There were approximately 500 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 1995 cropping season. Crop types and manure applications (starting in the fall of 1994) were also collected from the 1994 season for purposes of 1995 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.

Farm Size, Crop and Livestock Characteristics of the Selected Farms: Bevens and Sand Creeks Watersheds

Twenty-eight (28) farmers were interviewed October through December of 1995. Total inventoried acres by county (and number of farms per county) are as follows: Carver 3,588 (10); Scott 5,939 (9); Rice 643 (2); Sibley 978 (4); and Le Sueur 2,975 (3). Total area covered by the interviews was 14,123 acres with over 90% of the acres tillable (Table 1). Fourteen farms covering 4,566 acres are in the Bevens Creek watershed and 14 farms covering 9,557 acres are in the Sand Creek watershed. Average farm size was 505 acres.

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

Table 1. General description of all farms participating in the 1995 Bevens and Sand Creeks Watersheds nutrient management survey.

		Total Acreage Inventoried			Average Acreage by Farm		
County	Farms	Total	Crop	Noncrop[(1)]	Total	Crop	Noncrop
		Number of Acres					
Carver	10	3,588	3,046	542	359	305	54
Le Sueur	3	2,975	2,763	212	992	921	71
Rice	2	643	519	124	321	259	62
Scott	9	5,939	5,135	804	660	571	89
Sibley	4	978	853	125	244	213	31
Mean	**6**	**2,824**	**2,463**	**361**	**504**	**440**	**64**
Total	**28**	**14,123**	**12,316**	**1,807**			
Percent Total		**100%**	**87%**	**13%**			

(1) Noncrop includes pasture, CRP, Temporary Set Aside, building sites and other non-tilled acres in 1995.

Twenty-six (92%) farms had some type of livestock with dairy as the predominant livestock in this survey. Sixteen farmers had strictly dairy operations and two farmers had dairy/hog operations. Three farmers raised either dairy heifers or steers and four farmers raised strictly hogs. The final farmer with livestock raised a combination of beef, hogs and sheep. Approximately 3,200 dairy animals (including steers and heifers), 16,000 hogs, 50 beef, and 50 sheep were inventoried.

Fifteen (53%)[3] farmers had some type of liquid manure system while eleven (47%) farmers hauled manure only as solids; either as daily haul or manure pack from barns or lots. Often some temporary stacking of manure occurred short term until field space opened up. Liquid storage was dominated by earthen pits for dairy operations and pits under barns for hog producers.

Corn acres occupied approximately 53% of crop land. Soybeans and alfalfa covered approximately 34% and 11% respectively[4] (Figure 2). County specific data is given in Table 2.

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[3] Percent of farms with livestock

[4] Small grain seeded with alfalfa was considered alfalfa.

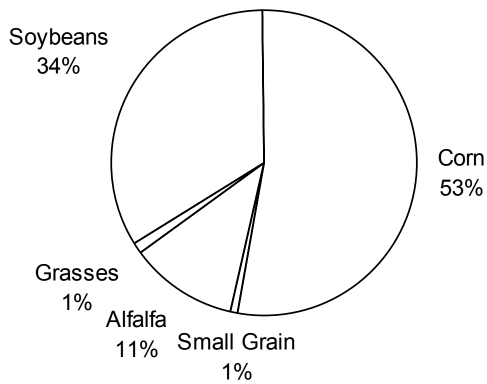

Figure 2. Crop type distribution across all cropland acres of all 28 farms.

Table 2. Average distribution of cropland acres per farm by county - 1995.

County	Corn	Soybeans	Alfalfa	Grasses	Small Grains	Sorghum	Other	Total
	Acres							
Carver	1,599	617	742	61	27	0	0	3,046
Le Sueur	1,330	1,328	20	0	76	0	9	2,763
Rice	231	136	140	8	0	4	0	519
Scott	2789	1,835	390	58	12	25	26	5,135
Sibley	476	280	97	0	0	0	0	853
Mean	**1,285**	**839**	**278**	**25**	**23**	**6**	**7**	**2,463**
Total	**6,425**	**4,196**	**1,389**	**127**	**115**	**29**	**35**	**12,316**
Percent Of Total	**52.2**	**34.1**	**11.3**	**1.0**	**1.0**	**0.2**	**0.3**	**100.0**

Commercial Fertilizer Use Characteristics on Selected Farms: Bevens and Sand Creeks Watersheds

Corn accounted for 99% of the total N commercial fertilizer use. Ninety-six percent (96%) of the total corn acreage received commercial N fertilizer (Table 3). Average fertilizer N rate on corn acres was 136 lb/A[5]. This rate is calculated as the means across all commercially N 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. Approximately 15% of the soybean acreage received N fertilizer. The average N rate on N fertilized soybeans was 8 lb/A (Table 3 and Figure 3).

Table 3. Distribution of commercial nitrogen and phosphate applications on cropland - 1995.

Crop	Acres Receiving N Fertilizer	Total N Applied (LBS X 1000)	Acres Receiving Phosphate Fertilizer	Total Applied P_2O_5 (LBS X 1000)
Corn	6,197	840.8	5,153	180.9
Soybeans	637	4.9	637	13.6
Alfalfa	168	2.3	255	8.5
Grasses	11	.6	11	1.3
Small Grains	48	2.7	30	1.2
TOTALS	**7,067**	**851.7**	**6,086**	**205.5**

5 Average commercial fertilizer rate across all corn acres, fertilized and non-fertilized, was 131 lb/A.

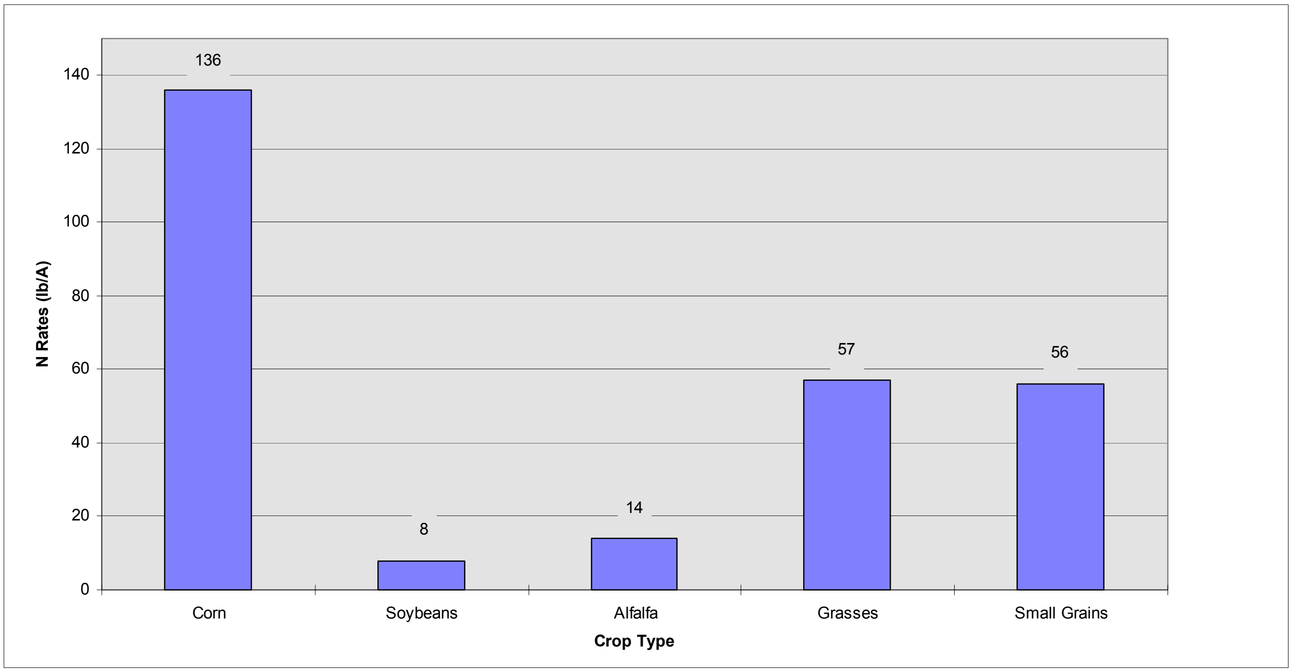

Figure 3. Average Commercial N fertilizer rates on crop acreage receiving N fertilizer.

Corn accounted for 88% of the total P_2O_5 commercial fertilizer use. Eighty percent (80%) of the total corn acreage received commercial P_2O_5 fertilizer (Table 3). Average fertilizer P_2O_5 rate on corn acres was 35 lb/A[6]; this rate is calculated as the means across all commercially P_2O_5 fertilized corn acres regardless of past manure P_2O_5 credits. Total P_2O_5 inputs will be discussed later in the "Nitrogen Balances and Economic Considerations" section. Approximately 15% of the soybean acreage received P_2O_5 fertilizer. The average P_2O_5 rate on P_2O_5 fertilized soybeans was 21 lb/A (Table 3 and Figure 4).

[6] Average commercial fertilizer rate across all corn acres, fertilized and non-fertilized, was 28 lb/A.

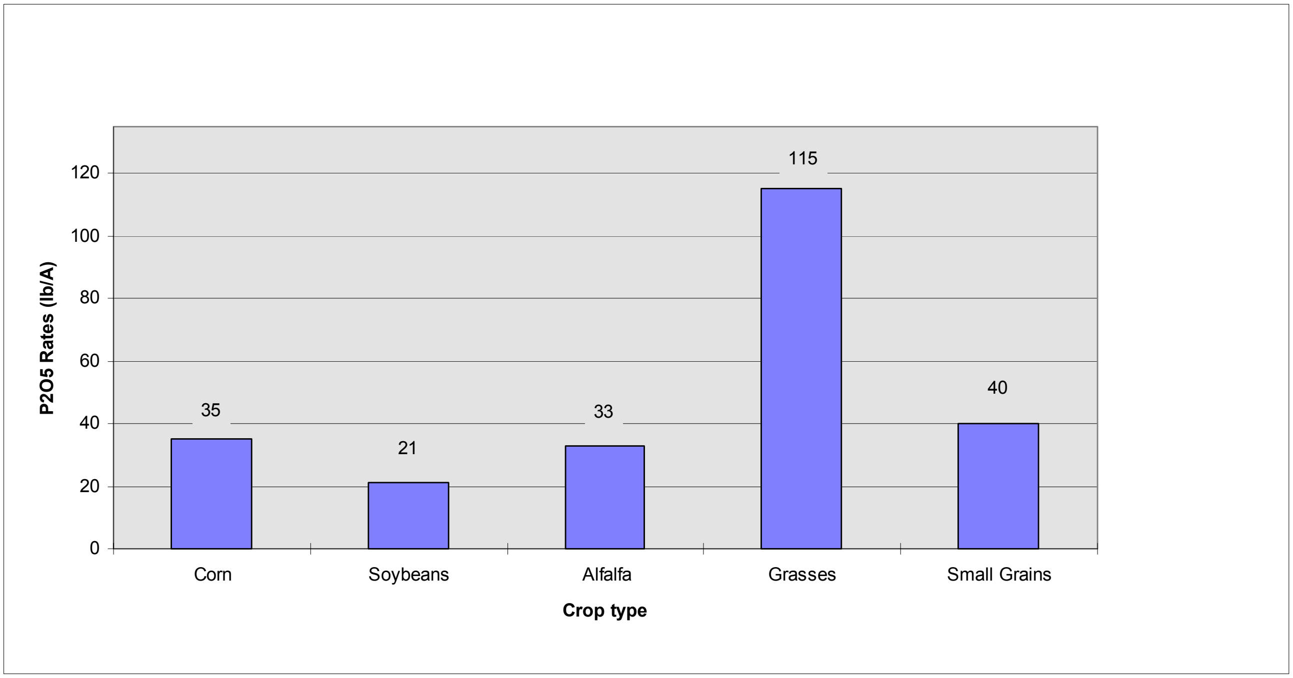

Figure 4. Average P_2O_5 fertilizer rates across acres fertilized with P fertilizer, by crop type.

Timing of N fertilizer applications is an important consideration in maximizing fertilizer use efficiency and minimizing environmental effects. Spring preplant applications of nitrogen in the form of anhydrous ammonia or urea are recommended for South-Central Minnesota[7]. Approximately 75% of commercial nitrogen fertilizer was applied as a spring preplant in the form of anhydrous ammonia or urea on acres planted to corn (Table 4).

Table 4. Timing of fertilizer applications for nitrogen on fertilized corn acres.

Growth Stage	Average Date of N Application	Total Acres Applied	Total N Applied (LBS X 1000)
Fall	11/4/94	2,996	154.0
Spring Preplant	4/30/95	4,895	634.4
Starter	5/7/95	4,297	51.1
Emergence	5/1/95	20	1.2
Side Dress	--	0	0
TOTALS			**840.7**

[7] M.A. Schmitt and G.W. Randall 1993. Best Management Practices for Nitrogen Use in South-Central MN. AG-FO-6127-B.

Fall application of nitrogen for corn in Central Minnesota is recommended if the proper source (anhydrous ammonia) is selected and proper soil temperature is reached. Research indicates anhydrous ammonia is the most efficient source of nitrogen when used for fall fertilization in South-Central Minnesota[8]. Producers applied 18% of the total nitrogen for corn during fall applications of 1994 for the 1995 growing season. In this survey, 95% of fall-applied nitrogen for corn was in the form of anhydrous ammonia and 20% of the anhydrous ammonia was applied with a nitrification inhibitor. Average fall application date of anhydrous ammonia without a nitrification inhibitor was November 4. Similarly, the average application date of anhydrous ammonia with a nitrification inhibitor was November 6. Fall-applied anhydrous ammonia accounted for 17% of the total commercial N applications on acres planted to corn.

Fall applications of anhydrous ammonia should be delayed until the soil temperature is below 50 F at the 6-inch depth. Long-term climatic data from the Waseca Experiment Station indicate that soil temperatures will generally remain below 50 F after October 29 respectively. Forty-four percent of fields fertilized with anhydrous ammonia were applied nitrogen before October 29. Delaying fall application of anhydrous ammonia fertilizer until after October 29 may reduce leaching of nitrogen.

Only 864 acres(15%) of the 5,891 acres planted with crops other than corn were applied with N fertilizer. Soybeans accounted for 46% of "non-corn" commercial N while alfalfa and small grains accounted for 25% and 26%, respectively.

Anhydrous ammonia supplied 80% of the total amount of commercial N applied to corn (Figure 5). Seventy-eight percent (78%) of anhydrous ammonia was applied as a spring preplant and the balance was fall-applied. Average N per application in fall was 138 lb/A and the average N per application in spring was 147 lb/A.

[8] M.A. Schmitt and G.W. Randall 1993. Best Management Practices for Nitrogen Use in South-Central MN. AG-FO-6127-B.

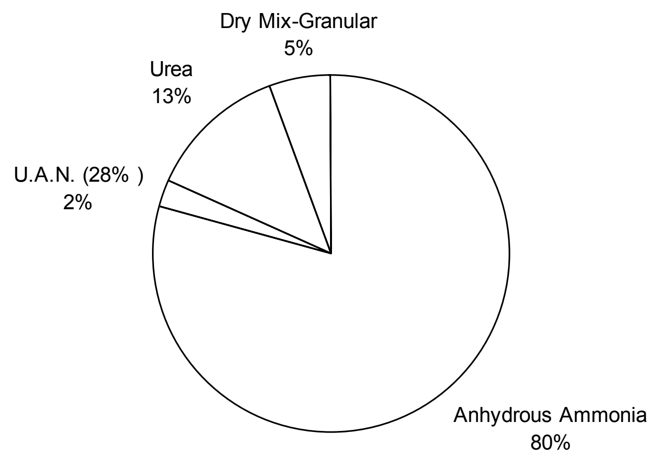

Figure 5. Contributions of N from various fertilizer sources on selected farms for corn.

Farmers were also asked how they determined the amounts of fertilizer to apply. Several choices were offered as to who assisted in the recommendations of fertilizer amounts. Those choices included: farmer knowledge; fertilizer companies; crop consultant; seed companies; extension agents; University of Minnesota data or brochures; other (with an open blank where the farmer could describe the source of recommendations).

Eight farmers (29%) relied solely on “farmer knowledge” or information from past years, talking to neighbors, or other sources to adjust the amounts applied in the past. Nine farmers (32%) relied solely on the fertilizer companies for their recommendations of amounts of fertilizer to apply. These farmers generally followed what the fertilizer company recommended. Nine farmers (29%) used their knowledge and the fertilizer dealers recommendation to come to an agreement as to the amount of fertilizer to apply. Two farmers (7%) used recommendations from crop consultants with one of those farmers adjusting the crop consultants recommendations as he felt necessary. None of the farmers used seed companies, extension agents, University of Minnesota data or brochures, or other sources for recommendations of fertilizer amounts.

Livestock and Manure Characteristics of the Selected Farms: Bevens and Sand Creeks Watersheds

Factors directly affecting crop 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. Table 5 includes a complete animal inventory, including estimates of N, P_2O_5 and K_2O produced[9] and collected in various types of manure systems for spreading on acres in the survey (manure collected but spread on acres not in the survey are not considered in the collected amounts). Manure not collected from the cattle is usually due to time spent on pastures and large lots where manure is not collected. Manure amounts collected from hogs is less than that produced due to producers with hogs raised off-site and the manure is not available for spreading on acres in the survey.

Dairy population counts represent the average number of animals on hand per year. Boars and sows are also recorded as the average number of animals on hand per year. Hog feeders and finishers are the number of animals sold per year. Beef calves raised to one year and beef calves purchased for raising are also the number of animals sold per year. All other beef numbers are recorded as the average number of animals on hand per year. Animals were recorded as animal numbers sold per year when the time on the farm was often less than one year.

Table 5. 1994 livestock numbers, and manure N, P_2O_5 and K_20 produced and collected by livestock types in sample population.

Livestock Type	Livestock Number	Manure Nitrogen Produced	Manure Nitrogen Collected	Manure P_2O_5 Produced	Manure P_2O_5 Collected	Manure K_2O Produced	Manure K_2O Collected
		Pounds X 1000		Pounds X 1000		Pounds X 1000	
Dairy Cows	1,338	269.6	232.7	109.0	94.1	217.4	187.7
Dairy Calves	754	50.0	44.4	23.1	20.5	37.1	33.0
Replacement Heifers	664	81.8	56.7	30.8	21.4	71.0	49.3
Dairy Steers	375	58.1	56.1	23.2	22.4	46.5	44.9
Boars	30	1.0	1.0	0.7	0.1	0.7	0.7
Sows	518	13.5	13.5	9.3	9.3	9.3	9.3
Feeder to Finishers	7,600	63.9	17.7	45.6	12.6	49.2	13.6
Farrow to Finisher	7,890	73.9	73.9	51.9	51.9	55.7	55.7
Beef Bulls	1	0.2	0.1	0.1	0.0	0.1	0.0
Beef Cows	25	3.3	1.1	2.5	0.8	2.9	1.0
Beef Feeders	20	1.7	0.6	1.2	0.4	1.6	0.5
Sheep Ewes and Rams	24	0.4	0.2	0.1	0.0	0.3	0.2
Feeder Lambs	30	0.2	0.1	0.1	0.0	0.2	0.1
TOTAL	**19,269**	**617.4**	**498.0**	**297.8**	**234.3**	**492.2**	**396.0**

9 Livestock Waste Facilities Handbook, Midwest Plan Services, Iowa State University, Ames, Iowa. 1993.

Estimated amounts of N, P_2O_5 and K_20 **per farm** produced from all livestock averaged 22,051, 10,634 and 17,578 pounds, respectively . Dairy livestock generated approximately 74% of the associated N (Figure 6) and 62% of the associated P_2O_5 (Figure 7).

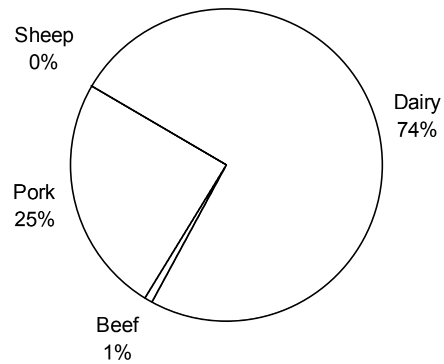

Figure 6. Amounts of nitrogen (total) generated by animal types across all selected farms. Total N produced was 22,051 pounds/farm.

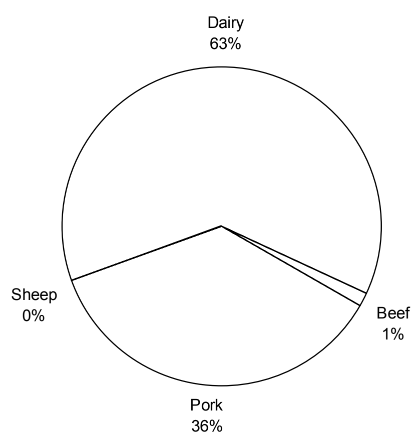

Figure 7. Amounts of P_2O_5 generated by animal types across all selected farms. Total P_2O_5 produced was 10,634 pounds/farm.

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 28 farms can be best categorized as 20 liquid systems and 61 solid systems.

For purposes of this report, the following storage system 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; *Treatment lagoon*- Similar to an earthen pit but often not lined with clay or other impervious material and often much larger enabling less frequent manure hauling; *Slurry Store*-Above ground steel tanks which are generally emptied once or twice per year; Cement tanks above ground-Similar to a Slurry Store and also emptied once or twice per year. Tanks are generally not covered.

Amounts of N and P_2O_5 collected, lost in storage, and amounts retained for land application are summarized by collection systems in Table 6. Based on the N collected (Figure 8), collection systems of livestock producers on South Central Minnesota farms are equally divided between solid and liquid manure. It appears that producers have the equipment facilities to store roughly one-half (50%) 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 daily scrape and haul system, based on nutrients generated, contributes less than 16% of the manure produced. A more serious challenge is the animal barns and yards that may be cleaned and hauled every one to four weeks throughout the year. Yards and barns account for approximately 32% of the total N retained.

Table 6. Manure N, P_2O_5 and K_2O collected and storage losses by all livestock on all farms in 1994.							
System Type	**Number of Systems**	**Manure Nitrogen Collected**	**Retained N After System Losses**	**Manure P_2O_5 Collected**	**Retained P After System Losses**	**Manure K_2O Collected**	**Retained K After System Losses**
		Pounds X 1000		**Pounds X 1000**		**Pounds X 1000**	
Daily Scrape/Haul	9	77.2	56.0	31.3	31.3	62.2	62.2
Unpaved Lot	2	4.8	2.4	2.5	1.4	4.1	2.6
Paved Lot	5	21.1	11.6	8.3	5.4	17.3	13.0
Animal Barn	26	92.9	65.0	42.2	42.2	72.9	72.9
Paved Pad	3	13.1	8.5	7.4	6.6	10.2	9.2
Pit Under Barn	10	125.5	97.2	75.2	75.2	97.3	97.3
Slurrystore	1	12.5	10.0	5.1	5.1	10.1	10.1
Earthen Pit	9	94.4	66.1	38.1	38.1	76.4	76.4
Half Barn/Half Lot	16	56.4	33.9	24.3	19.4	45.7	41.1
TOTALS	**81**	**498.0**	**350.8**	**234.3**	**224.7**	**396.0**	**384.7**

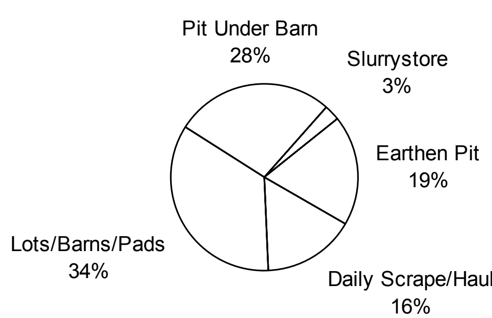

Figure 8. Contributions of total **nitrogen retained after storage losses** by type of manure collection system.

Liquid storage systems contributed to a slightly higher percentage of the retained P_2O_5 when compared to retained N (Figure 9). Nitrogen retained was 70% of the N collected and P_2O_5 retained was 96% of the P_2O_5 collected.

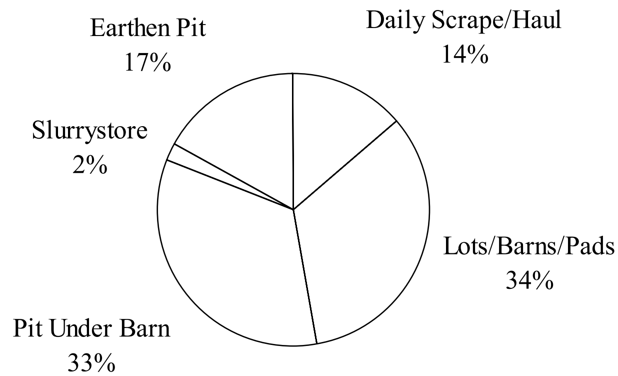

Figure 9. Contributions of total **P_2O_5 retained after storage losses** by type of manure collection system.

Nutrient losses from collection and storage were estimated from accepted guidelines[10] for each individual storage system. Losses as a function of application methods and timing factors were calculated on a field-by-field basis (Table 7)[11]. Manure generated a total of 110,000 lb of "first year available" N. This represents 3,900 lb/N/farm.

The fate of manure-N has been summarized in a simple flow diagram (Figure 10). This diagram simplifies the complexities associated with N from excretion to "plant available". Figure 11 summarizes the fate of manure-P_2O_5. Eighteen percent of the N produced was available for crop use compared to 65% of the P_2O_5 produced was available for crop use. Approximately two-thirds of the "first year available" N (on a weight basis) was applied to corn (Figure 12). Soybeans (18%) and alfalfa (14%) received the bulk of the difference. Out of all the corn acres in the survey, only 26% received manure applications (Table 7).

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[10] Livestock Waste Facilities Handbook, Midwest Plan Services, Iowa State University, Ames, Iowa. 1993.

[11] M. Schmitt, and G. Rehm. Fertilizing Cropland with Dairy Manure. FO-5880-C. M. Schmitt, and G. Rehm. Fertilizing Cropland with Swine Manure. FO-5880-C. M. Schmitt, and G. Rehm. Fertilizing Cropland with Beef Manure. FO-5880-C.

Table 7. Distribution of first year available farm generated manure to cropland in 1995[12].						
Crop[13]	**Manured Acres**	**Total Acres**	**% of Acres**	**Available N**	**Available P_2O_5**	**Available K_20**
				Pounds X 1000		
Corn	1,672	6,425	26%	71.3	121.3	199.0
Soybeans	482	4,196	11%	19.8	37.2	49.9
Alfalfa	441	1,389	32%	15.5	26.5	52.1
Grasses	0	127	0%	0	0	0
Small Grains	21	115	18%	1.0	1.6	2.1
Sorghum	4	29	14%	0.1	0.1	0.2
Other	0	35	0%	0	0	0
Set Aside	84	117	72%	2.4	5.3	7.9
Pasture	87	236	37%	0.3	0.8	1.6
Crop Total	**2,620**	**12,316**	**21%**	**107.7**	**186.6**	**303.4**
All Acres Total	**2,791**	**12,669**	**22%**	**110.4**	**192.7**	**312.9**

12 M. Schmitt, and G. Rehm. Fertilizing Cropland with Dairy Manure. FO-5880-C. M. Schmitt, and G. Rehm. Fertilizing Cropland with Swine Manure. FO-5880-C. M. Schmitt, and G. Rehm. Fertilizing Cropland with Beef Manure. FO-5880-C.

13 Set aside and pasture acres were not considered in cropland acres but are considered in acres were manure is spread.

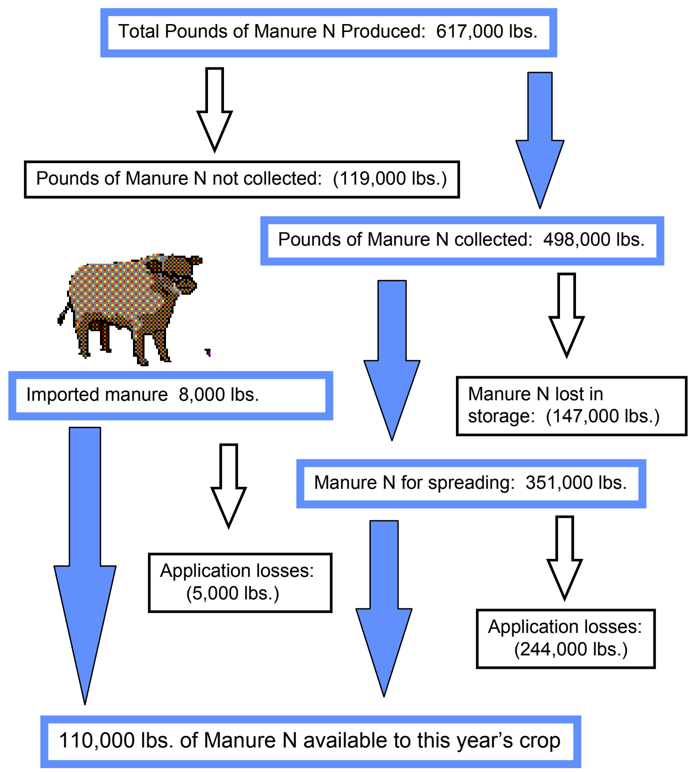

Figure 10. Fate of farm generated and imported manure-N across all storage and management factors.

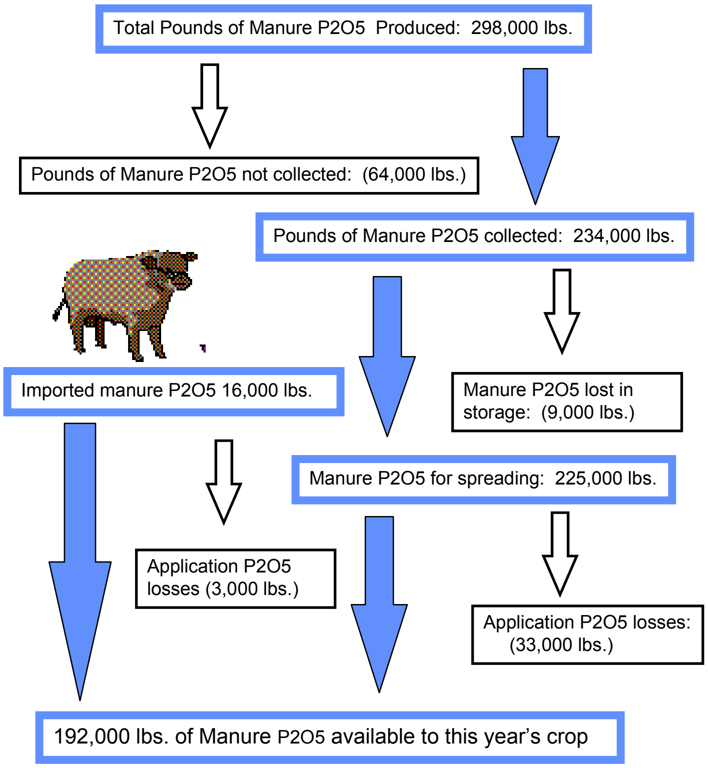

Figure 11. Fate of farm generated and imported manure- P_2O_5 across all storage and management factors.

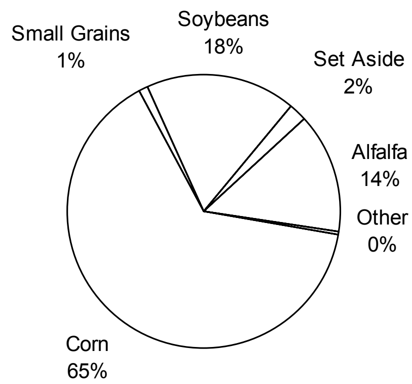

Figure 12. Distribution of "first year available" nitrogen by crop type calculated on a weight basis.

Fifty-seven percent (57%) of the farm generated manure on corn acres was applied as a broadcast with no incorporation[14]. Incorporation of broadcast manure within 4 days would increase the retained N available for crop use by 50%. Twenty-one percent (21%) of the manure was incorporated within 4 days and 22% of the manure was knife-injected.

Thirty-seven percent of the manure[15] applied came from storage facilities of 6 months storage capacity or longer and was applied in spring and/or fall. Another 31% of the manure was applied during fall and spring but came from storage systems with less than 6 months capacity. The balance of the manure was spread in the summer (16%) and winter (16%) Application timing of all manure applied to corn acres, regardless of storage system, is shown in Figure 13. In this report spring applications are defined as manure applied during March through May, summer applications were applied during June through August, fall applications were applied during September through November and winter applications were applied during December through February.

[14] Based on total N available from all farm generated manure after storage losses have been subtracted.

[15] Based on total N available from all farm generated manure after storage losses have been subtracted.

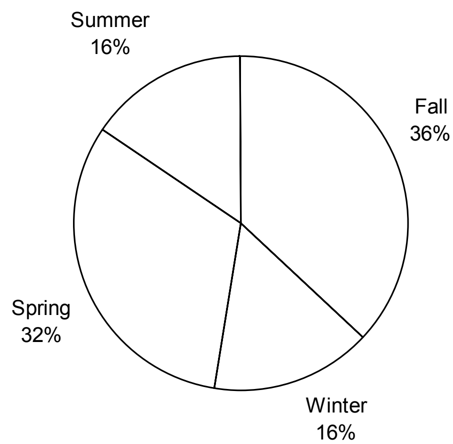

Figure 13. Timing of manure applications on corn acres based on total N available.

Manure testing is a critical component in nutrient management planning. Two (7%) of the 26 farmers with livestock had done some manure testing prior to this project. Participants were offered well water and manure testing as part of the program. The U. S. drinking water standard for nitrates is 10 ppm. Eighteen wells were tested for nitrates and none of the wells had nitrate levels above 1 ppm.

Due to the high variability of N, P_2O_5 and K_20 found in manure systems, individual tests greatly enhanced the value of the on-farm nutrient balance. Twenty-two manure samples were analyzed for N, P_2O_5 and K_20. The average results for all liquid and solid systems are shown in Table 8.

Table 8. Analysis of 22 Manure Samples.

	Average Analysis of Samples					
Animal Type	**Solid Systems Pounds per Ton Total Nutrients**			**Liquid Systems Pounds per 1000 Gallons Total Nutrients**		
	N	**P_2O_5**	**K_20**	**N**	**P_2O_5**	**K_20**
Hogs	18	13	14	59	30	37
Dairy	16	12	29	37	24	34
Beef	10	10	10	--	--	--
Sheep	22	11	31	--	--	--

Relative Importance of N and P Sources on the Selected Farms: Bevens and Sand Creeks Watersheds

University of Minnesota recommendations for nitrogen provide N credits from legumes. Alfalfa was assumed to have 2-3 plants per square foot when tilled for the following corn crop. First year alfalfa provided a 75 lb/A credit, and second year alfalfa provided a 50 lb/A credit. Soybeans provided a 40 lb/A credit. These N credits will later be compared to the reductions in nitrogen on corn acres with no legume N credits to those corn acres with legume N credits. In the Bevens and Sand Creeks survey, soybeans were by far the most important source of legume N, supplying approximately three-fourths of all legume N. Alfalfa (first and second year credits) supplied the balance.

Commercial fertilizer (74%), manure (6%), and legume (20%) contributed a total of 1,138,000 pounds of "first year available N" to **corn acres** (Figure 14). This is an average N rate of 177 lb/A across all corn acres. Proper crediting for these sources is critical in maintaining economic and environmental balances.

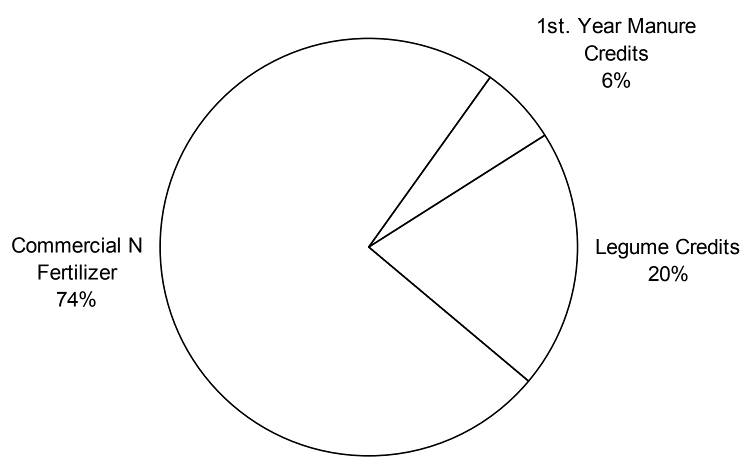

Figure 14. Relative N contributions from fertilizers, manures and legumes across all corn acres. N inputs totaled 1,138,000 for all sources. N contributions averaged 177 lb/A across all corn acres.

Nitrogen Balances and Economic Considerations: Bevens and Sand Creeks Watersheds

The corn yield goal across all 28 farms in the five counties averaged 154 bushels/A. University of Minnesota N recommendations (based on yield goal, crop history, and soil organic matter level) were compared to actual amounts of fertilizer and manure applied to each field. Approximately 2,500 acres had soil tests with soil organic matter data and 97% of those acres were in the medium and high range. Analysis of corn acres was based on the assumption all corn acres had organic matter levels in the medium to high range. University of Minnesota N recommendations to fulfill this goal averaged 104 lb/N/A (Figure 15). Actual amounts of N applied from fertilizer and manure averaged 131 lb N/A and 11 lb/A respectively across all corn acres. Factoring in all appropriate credits from fertilizer, legumes and manures, there was an over-application rate of 38lb/N/A.

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 (1994[16]) to accurately credits these sources.

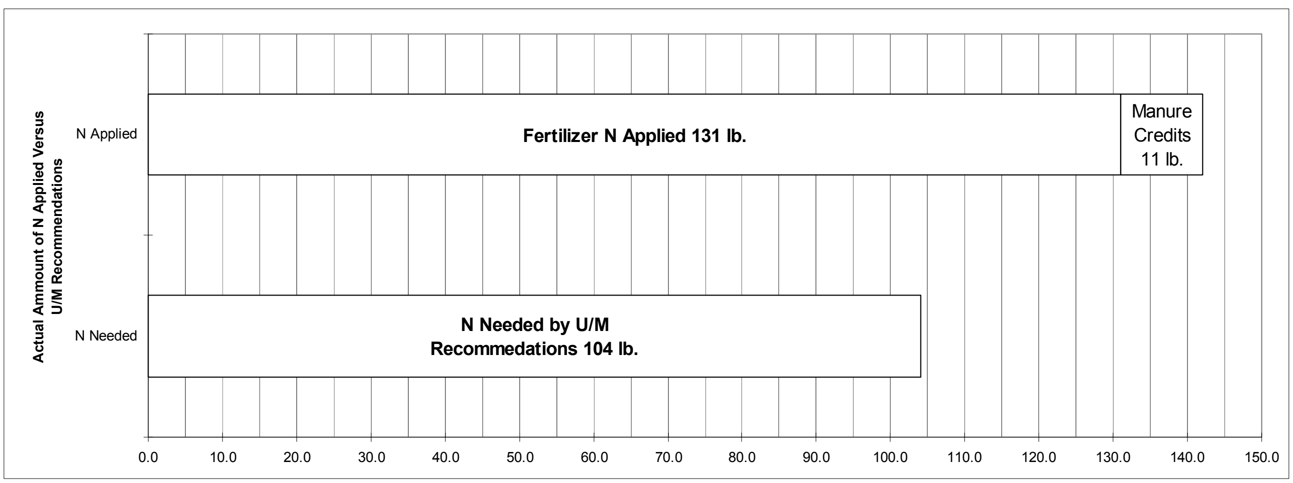

Figure 15. Crop N requirements based on University of MN recommendations in comparison to actual N inputs (fertilizer, and manure) across all corn acres. Total corn area in this analysis was 6,425 acres. Legumes also provided 35 lb/A N across all acres and is already reflected in the UM recommendations.

Balances were examined in more detail by lumping the **1995 corn acreage** into eight different scenarios:

16 Referring to any manure applications prior to those made in the fall of 1994.

Scenario 1: N from fertilizer only; no legume or manure credits;
Scenario 2: N from fertilizer; no legume credits; manure applied.
Scenario 3: Previously soybeans (1994); no manure applied;
Scenario 4: Previously soybeans (1994), manure applied;
Scenario 5: Previously alfalfa (1994); no manure applied;
Scenario 6: Previously alfalfa (1994); manure applied.
Scenario 7: Previously alfalfa (1993); no manure applied;
Scenario 8: Previously alfalfa (1993); manure applied.

Nitrogen balances for all corn acres are broken down into these scenarios in Table 9. Fertilizer N rates specific to each of the scenarios are illustrated in Figure 16. The commercial N rates in scenario 1 (no legumes, no manure) averaged 141 lb/A. One method to determine the credits attributed to the various organic contributions is to compare the subsequent commercial N rates.

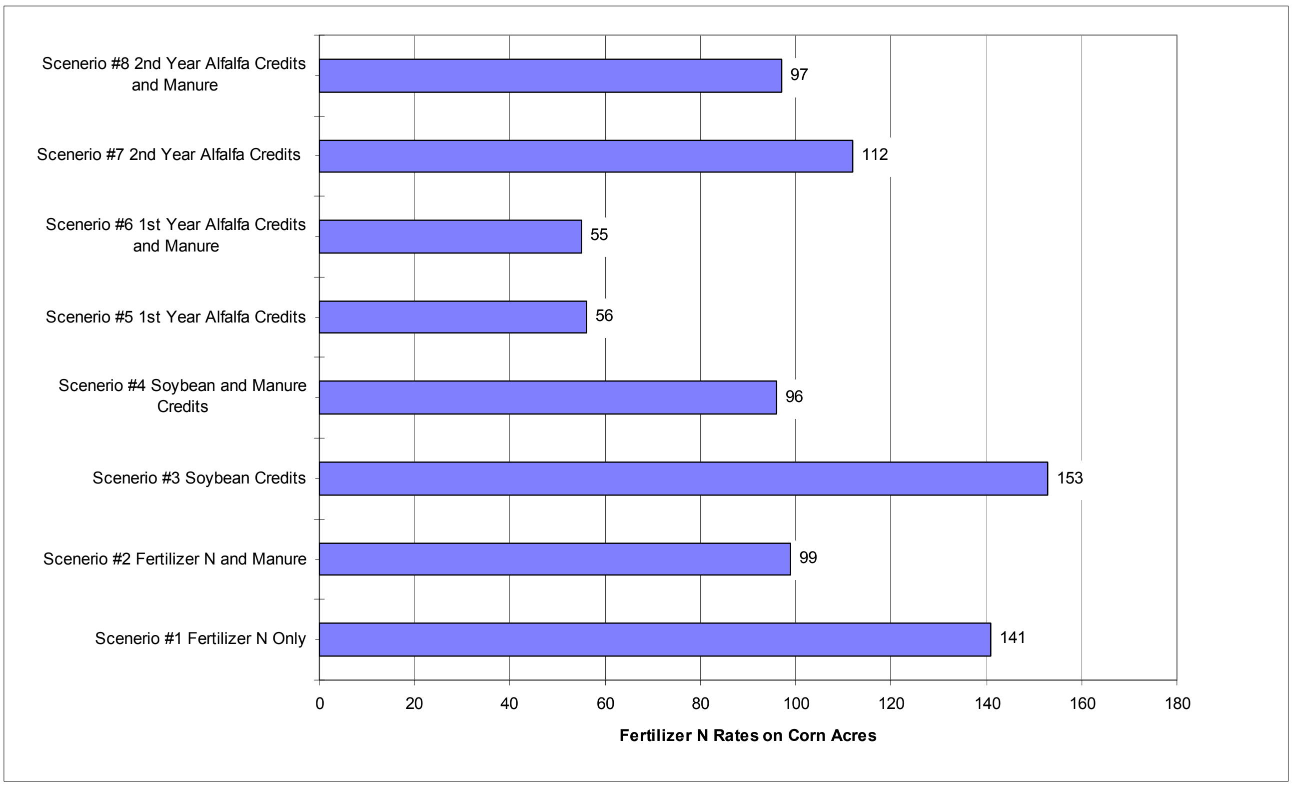

Figure 16. Commercial fertilizer N rates on corn by management scenario. See definitions for complete description of rotation and land application details.

Table 9A.
Nitrogen Inputs and Balances-Average Nitrogen-Across All South-Central Areas

Scenario Number	Total Acres	Legume credits (lb/A)	Legume Credits Total	Manure N (lb/A)	Manure Total	Fert N (lb/A)	Fert Total	N Rec. (lb/A)	N Rec. Total	Excess (lb/A)	Yield Goal
1	653	0	0	0	0	141	92,225	138	89,950	3	153
2	687	0	0	49	33,417	99	68,327	138	94,910	10	154
3	3,693	40	147,720	0	0	153	566,305	100	368,460	54	155
4	508	40	20,320	38	19,143	96	48,877	104	52,650	30	154
5	229	75	17,175	0	0	56	12,860	66	15,180	(-10)	150
6	330	75	24,750	37	12,046	55	18,030	65	21,360	26	153
7	178	50	8,900	0	0	112	19,965	83	14,850	29	148
8	147	50	7,350	45	6,676	97	14,196	91	13,310	51	156
TOTALS FOR ALL SCENARIOS	**6,425**	**35**	**226,215**	**11**	**71,280**	**131**	**840,786**	**104**	**670,670**	**38**	**154**

Table 9B.
Nitrogen Inputs and Balances-Excess Nitrogen-Across All South-Central Areas

Scenario Number	Total Acres	Legume credits (lb/A)	Legume Credits Total	Manure N (lb/A)	Manure Total	Fert N (lb/A)	Fert Total	N Rec. (lb/A)	N Rec. Total	Excess (lbs/A)	Excess Total
1	422	0	0	0	0	159	67,154	136	57,310	23	9,844
2	444	0	0	50	22,321	139	61,775	138	61,140	52	22,956
3	3,397	40	135,880	0	0	160	542,003	99	335,110	61	206,903
4	412	40	16,480	33	13,732	119	48,876	104	42,970	48	19,639
5	85	75	6,375	0	0	113	9,571	63	5,355	50	4,216
6	191	75	14,325	42	7,986	87	16,675	58	10,995	72	13,666
7	147	50	7,350	0	0	132	19,407	80	11,750	52	7,657
8	110	50	5,500	48	5,247	126	13,863	85	9,330	89	9,780
TOTALS FOR ALL SCENARIOS	**5,208**	**36**	**185,910**	**9**	**49,286**	**150**	**779,356**	**103**	**533,960**	**57**	**294,682**

Table 9C.
Nitrogen Inputs and Balances-Shortage Nitrogen-Across All South-Central Areas

Scenario Number	Total Acres	Legume credits (lb/A)	Legume Credits Total	Manure N (lb/A)	Manure Total	Fert N (lb/A)	Fert Total	N Rec. (lb/A)	N Rec. Total	Shortage (lb/A)	Shortage Total
1	231	0	0	0	0	108	25,071	141	32,640	32	7,568
2	245	0	0	46	11,095	26	6,552	139	33,770	66	16,122
3	296	40	11,840	0	0	82	24,272	113	33,350	31	9,078
4	96	40	3,840	56	5,410	0	0	101	9,680	44	4,270
5	144	75	10,800	0	0	23	3,288	68	9,825	45	6,536
6	139	75	10,425	29	4,060	10	1,355	75	10,365	36	4,951
7	31	50	1,550	0	0	18	558	100	3,100	82	2,542
8	37	50	1,850	39	1,429	9	333	108	3,980	60	2,218
TOTALS FOR ALL SCENARIOS	**1,217**	**33**	**40,305**	**18**	**21,995**	**50**	**61,431**	**112**	**136,710**	**44**	**53,285**

Scenario Definitions:

Scenario 1: N from fertilizer only; no legume or manure credits;
Scenario 2: N from fertilizer; no legume credits; manure applied.
Scenario 3: Previously soybeans (1994); no manure applied;
Scenario 4: Previously soybeans (1994), manure applied;
Scenario 5: Previously alfalfa (1994); no manure applied;
Scenario 6: Previously alfalfa (1994); manure applied.
Scenario 7: Previously alfalfa (1993); no manure applied;
Scenario 8: Previously alfalfa (1993); manure applied.

The following comments are based completely on the net differences in fertilizer N inputs comparing corn fields receiving only fertilizer N (Scenario 1) to the other scenarios:

* Scenario #2: Corn acres with no legume credits and receiving manure credits had a decrease of 42 lb/A in commercial N fertilizer. Manure supplied an additional 49 lb/N/acre. Farmers, on average, were crediting almost all (86%) of manure N credits.

* Scenario #3: Producers did not reduce fertilizer inputs on fields previously in soybeans and not applied with manure. Fertilizer N rates in scenario 3 averaged 153 lb/A, an increase of 12 lb/A above the average fertilizer N rate of scenario 1 (no manure or legume credits). Yield goals were approximately the same between scenario 1 and scenario 3 at 153 and 155 respectively. Farmers in this category were on average taking no credits for soybeans. Based only on the N fertilizer replacement value, proper crediting could save these producers approximately $10/acre[17] ,on average, assuming no additional transportation and labor costs.

* Scenario #4 : Producers also reduced fertilizer inputs on manured corn fields previously in soybeans. Fertilizer N rates in scenario 4 were reduced by 45 lb/A compared to corn acres with no legume or manure credits (scenario 1) and by 57 lb/A compared to corn following soybeans without manure (scenario 3). Manure credits averaged 38 lb/N/acre across all fields. It appears farmers were taking most manure credits here also and some soybean credits.

* Scenario #5 : Producers reduced fertilizer inputs on corn fields previously in alfalfa. Fertilizer N rates in scenario 5 were reduced by 85 lb/A compared to corn acres with no legume or manure credits. Farmers appeared to be taking sufficient credits for alfalfa in this category.

* Scenario #6 : Producers reduced fertilizer inputs on manured corn fields previously in alfalfa. Fertilizer N rates in scenario 5 were reduced by 86 lb/A compared to corn acres with no legume or manure credits. Rates were reduced by approximately the same for fields previously in alfalfa regardless of manure.

* Scenario #7 : Producers reduced fertilizer inputs on corn fields previously in alfalfa in 1993 (second year credits) by 28 lb/A when compared to corn acres with no legume or manure credits.

* Scenario #8 : Producers reduced fertilizer inputs on manured corn fields previously in alfalfa in 1993 (second year credits) by 44 lb/A when compared to corn acres with no legume or manure credits. Producers were also reducing fertilizer N by 15 lb/acre compared to scenario 7, although manure credits contributed 45 lb/N/acre.

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17 Based on a nitrogen fertilizer price of $0.20/pound.

Factoring in legume N credits and manure N inputs into the process on a field-by-field basis, the amounts in excess of 1994 University of MN recommendations are illustrated in Figure 17. 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 9.

Eighty-one (81%) of the total corn acres were classified into the Excess category. Excess amounts of N averaged 57 lb/A across all acres in this category. The remaining acres (19%) were classified as Below[18] UM recommendations. Shortage amounts of N average 44 lb/A.

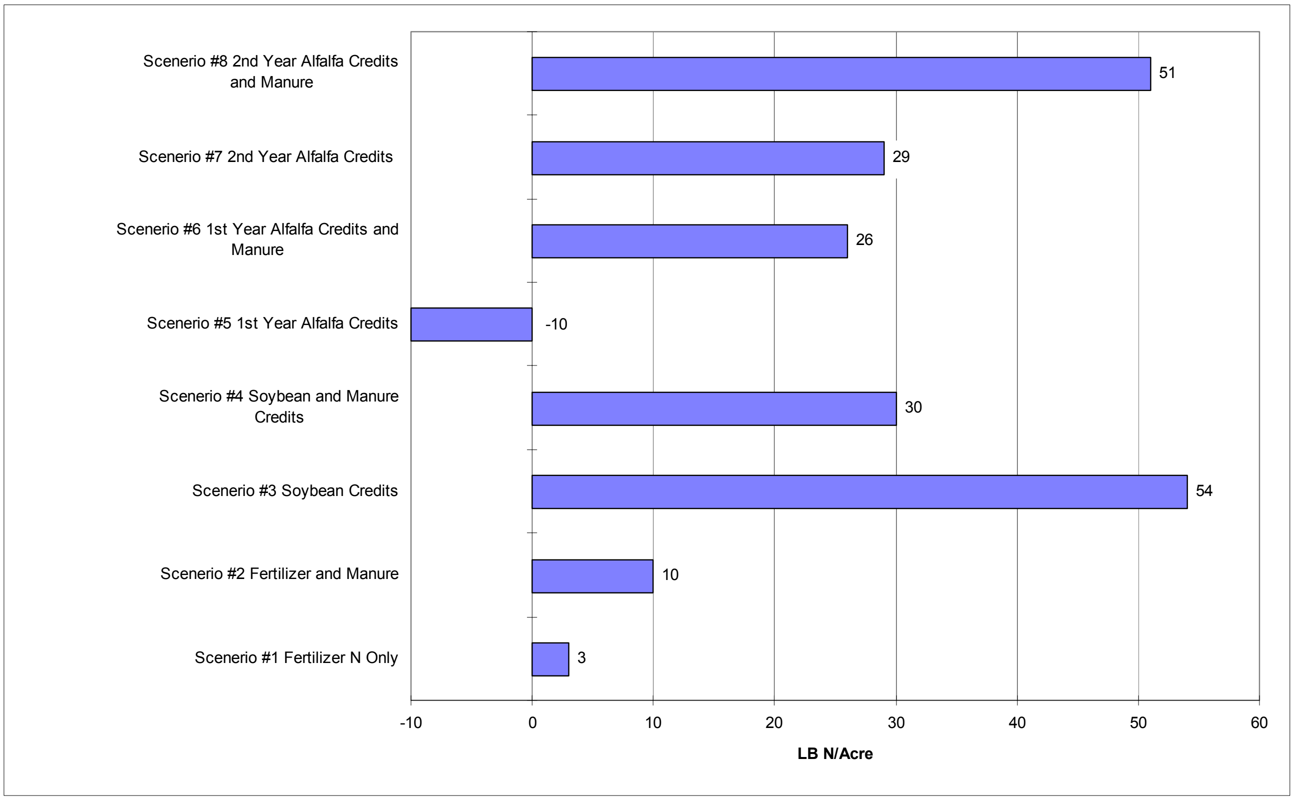

Figure 17. Nitrogen inputs in comparison to University of Minnesota recommendations across the different management scenarios for 1995. Analysis includes all 6,425 acres of corn.

18 Includes acres where amounts equal UM recs.

Viewing the distribution of excess N from a water quality perspective, a helpful indicator is the cumulative excess N values found in Table 9b. These figures factor in both the total acres of any given scenario as well as the rate of excess 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 soybeans (scenario #3) . Although scenario #3 accounts for 57% of the corn acres, it accounts for 70% of the excess N applied to corn acres. Figure 18 captures this concept by illustrating the relative excess N by the various management scenarios.

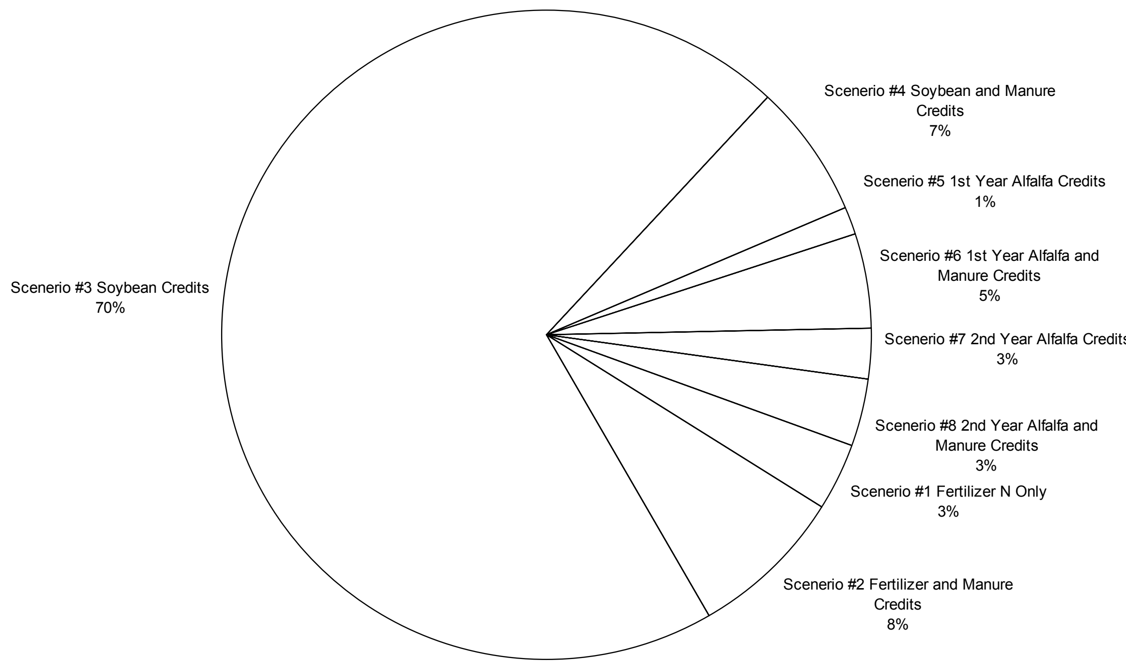

Figure 18. Relative contributions of total excess N by the different management scenarios across all corn acres.

Corn acres were also divided into categories according to how close the amount of N applied was to the amount of N recommended by the UM. There were 335 (5%) acres of corn within + or -10 lb/A of UM recommendations. Figure 19 further shows the distribution of all corn acres in comparison to the UM recommendations by categorizing the acres according to whether or not the N available was within + or -30 lb/A of UM recommendations. A + or -30 lb/A range on either side of the UM recommendations should allow for most site specific management decisions or problems such as the wet fall of 1994 or late spring of 1995 which may affect decisions on the amount of N to apply.

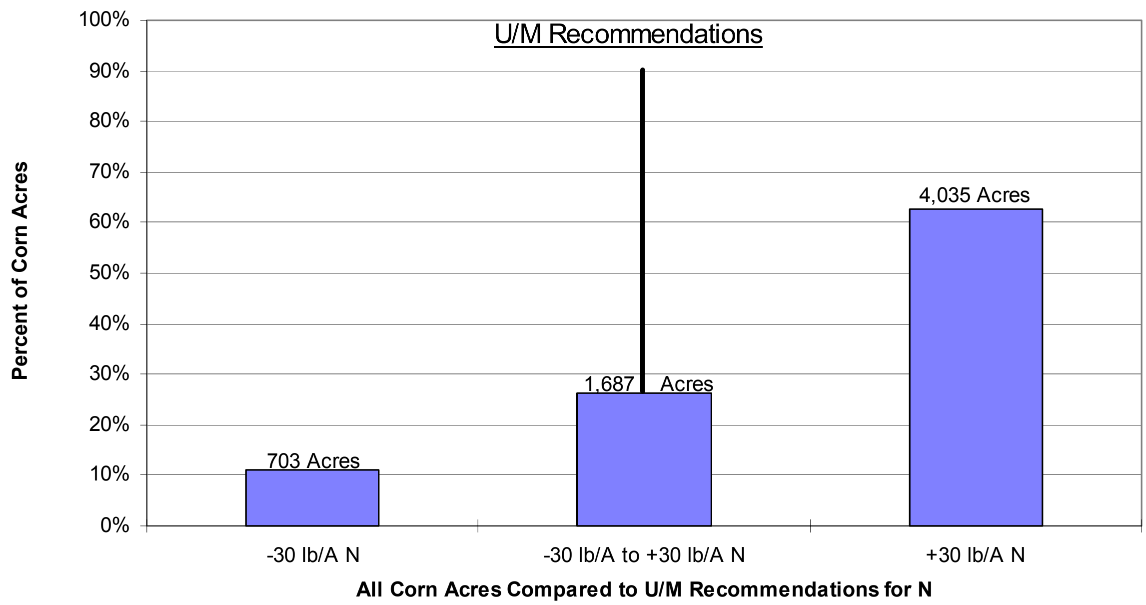

Figure 19. Percentage of the corn acres receiving N below, above and within + or - 30 lbs of UM recommendations.

Clearly the area where reductions of N inputs could be made is in the 63% of acres with N inputs exceeding UM recommendations by 30 lb/A or more. Table 10 describes the different scenarios in regard to excess amounts more than 30 lb/A above UM recommendations and the average reductions possible that would reduce N inputs to within 30 lb/A of recommendations. In most cases a reduction of fertilizer N would be possible to reduce the N inputs to within 30 lb/A of UM recommendations. Out of all manured crop acres, (2,620), only 172 acres (7%) had more N applied from manure than UM recommendations required for N[19]. Corn acres with manure in excess of UM recommendations plus 30 lb/N/A, totaled 32 acres (1%). On acres of corn with excess N from manure, reduction in the application rate of the manure applied in needed, and often reduction of fertilizer N.

[19] Some of these manured acres received N credits from legumes also.

Table 10. Potential N savings on corn acres where N inputs were more than 30/A above UM recommendations.			
Scenario	**Acres**	**Total Reduction of N Possible**	**Average Reduction of N Possible**
N From Fertilizer Only	63	325	5
N From Fertilizer And Manure	276	11,593	42
N From Fertilizer And Soybeans Credits	3,068	105,210	34
N From Fertilizer, Manure, And Soybean Credits	245	9,302	38
N From Fertilizer And First Year Alfalfa Credits	39	2,574	66
N From Fertilizer, Manure, And First Year Alfalfa Credits	123	8,696	71
N From Fertilizer And Second Year Alfalfa Credits	147	3,247	22
N From Fertilizer, Manure, And Second Year Alfalfa Credits	74	6,914	97
All Scenarios Totals and Averages	**4,035**	**147,861**	**37**

Corn acres were also divided into categories by who determined the amounts of fertilizer to apply. There were sufficient acres of corn following soybeans and corn following non-legumes to allow analysis on those acres by who determined the fertilizer recommendations. On corn following soybean acres, farmers using crop consultant recommendations for fertilizer applied N closest to the recommendations provided by the University of Minnesota at an average excess of 20 lb/N/acre average over all acres(Table 11). Farmers using past knowledge were also applying N fertilizer close to the UM recommendations at an average excess of 28 lb/N/acre. On acres corn following a non-legume crop, farmers who used recommendations only from fertilizer dealers applied fertilizer N at a rate of more than 25 lb/N/acre above UM rates. When corn followed soybeans or when corn followed a non legume crop, farmers who used recommendations from fertilizer companies over applied the largest amount of N per acre.

Table 11.
Nitrogen Balances-Average Nitrogen
By Who Determined The Fertilizer Amounts To Apply.

Crop	Who Determines Fertilizer Amounts	Acres	Fertilizer N Applied Per Acre	Total N (Includes Manure) (Credits)	Yield Goal	N Balance per Acre
Corn Following Soybeans	Farmer Knowledge	312	105	126	150	28
Corn Following Soybeans	Farmer Knowledge/Fertilizer Company	807	135	139	146	47
Corn Following Soybeans	Fertilizer Company	2,319	161	162	152	64
Corn Following Soybeans	Crop Consultant[20]	725	130	142	170	20
Corn Following Non-Legume	Farmer Knowledge	293	70	114	146	(-14)
Corn Following Non-Legume	Farmer Knowledge/Fertilizer Company	412	102	128	151	(-8)
Corn Following Non-Legume	Fertilizer Company	603	155	170	155	27
Corn Following Non-Legume	Crop Consultant	32	149	158	160	8

Soil test results were available for 2,461 (20%) of all 12,316 acres of cropland. A much larger percentage of the acres had recently been soil tested, but the tests were not available at the time of the interviews. Soil test results show an average organic matter of 5.1% across all soil tested acres. As stated earlier, 3% of the acres with soil test were in the low organic matter level (<3%) and 97% of the acres tested were in the medium or high level (>=3%). Figure 20 shows the pH levels on acres with soil tests. Ranges of soil tests were: below 5.5, 5.5 to 7.0 (which is the range P_2O_5 has the highest availability for plant uptake[21]), and above 7.0. $Bray_{p1}$ test was generally used for soil tests with pH levels below 7.3 and the Olsen test was generally used for soil tests with pH levels of 7.3 and above.

[20] Includes recommendations made by crop consultants alone and recommendations agreed upon between a crop consultant and the farmer.

[21] G. Rehm and M. Schmitt. Understanding Phosphorus In Minnesota Soils.

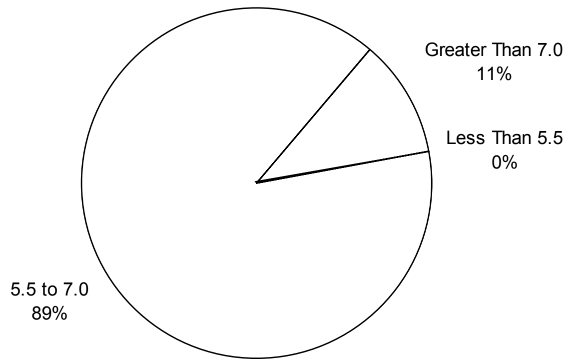

Figure 20. Range of pH levels from soil tests. Levels of pH from 5.5 to 7.0 provide the optimum range for highest uptake of phosphorus.

Soils in the study area tend to be high in native P and K. These subsoil levels have occurred naturally without man's influence. Figure 21 shows the P_2O_5 levels by the range in which each test fell[22]. Figure 22 shows the K_2O levels by the range in which each test fell[23]. In this analysis K_2O amounts were not a consideration, but the soil tests do provide a feel as to whether the K_2O from manure could replace K_2O from fertilizer.

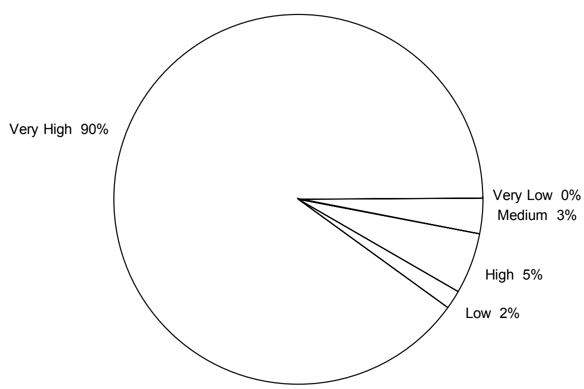

Figure 21. Soil test results of P_2O_5 levels. Ninety-five percent (95%) of the soil tests were in the high to very high range. Eighteen percent of the tests were Olsen tests and the remainder were $Bray_{p1}$ tests for measuring P_2O_5.

22 Ranges for P_2O_5 for $Bray_{p1}$ tests are: very low 0-5, low 6-10, medium 11-15, high 16-21, very high 21+. Ranges for P_2O_5 for Olsen tests are: very low 0-3, low 4-7, medium 8-11, high 12-15, very high 16+.

23 Ranges for the K_2O tests are: very low 0-40, low 41-80, medium 81-120, high 121-160, very high 161+.

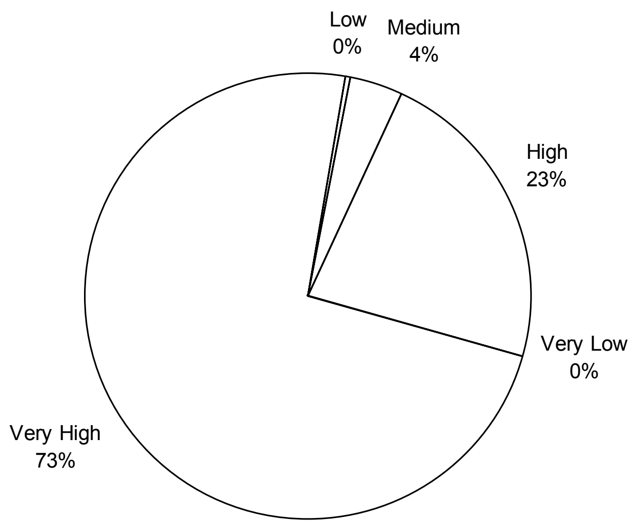

Figure 22. Soil test results for K_2O levels. Ninety-six percent (96%) of the soil tests were in the high to very high range.

Applications of P_2O_5 on corn acres with manure and without manure were 20 lb/A and 31 lb/A respectively. Although there was an 11 lb/A reduction of P_2O_5 on manured corn acres, manure contributed an additional 73 lb/A of P_2O_5 to each acre of manured corn. Applications of K_2O were collected and K_2O from fertilizer averaged 26 lb/A on manured corn acres and 80 lb/A on corn acres without manure. Manure contributed an additional 119 lb/A on corn acres receiving manure. Total K_2O from manure and fertilizer averaged 145 lb/A on manured corn acres and 80 lb/A on non manured corn acres.

The value of manure would be the greatest if placed on corn acres with the lowest P_2O_5 and K_2O levels, **and** reducing fertilizer rates on those acres (nutrients from the manure should replace those from commercial fertilizer). Assuming the soil tests represent most acres in the survey, the most value from the manure would be on corn acres (corn acres have the greatest need for nutrients in this survey) with P_2O_5 and K_2O levels in the very low to medium range, according to soil tests. Only 5% of the acres tested were in the very low to medium range with regard to P_2O_5 and less than 5% of the acres tested were in the very low to medium range in regard to K_2O. With an average contribution of 73 lb/A of P_2O_5 from manure corn acres receiving manure, the average farmer receives almost no replacement value from most of the P_2O_5 applied.

Tillage Practices and Residue Cover on Bevens and Sand Creeks Watersheds

Tillage practices are a critical component in trying to prevent runoff into surface water. An extremely high portion of the acres in the study area have very high soil P levels, leaving very few acres available for spreading manure if manure applications are based on soil P test results. Tillage on high P level soils is critical in preventing sediment from reaching surface waters.

Tillage was extensive on acres planted to corn as over 99% of all corn acres received some tillage. Only 11 acres of corn were planted as no-till. Tillage was also extensive on acres planted to soybeans as over 99% of all soybeans acres received some tillage. Less than 1% of soybean or corn acres were planted as no-till.

Primary tillage on corn acres was the use of a field cultivator (46%) followed by moldboard plow (22%) (Figure 23). Fall tillage was used on 3,353 of the 6,414 (52%) corn acres with tillage. Moldboard plow (42%), deep chisel/disk (DMI or equivalent) (28%), and chisel plow (27%) accounted for 97% (of all fall tilled acres. Field cultivators accounted for 85% of the spring tillage (Table 11). Figures 24 and 25 detail the breakdown of tillage practices on corn acres following soybeans and corn acres following another crop (other crops are generally corn or alfalfa). Spring tillage was generally used on corn following soybeans (70%) and fall tillage was generally used on corn following other crops such as corn following corn, or corn following alfalfa (95%).

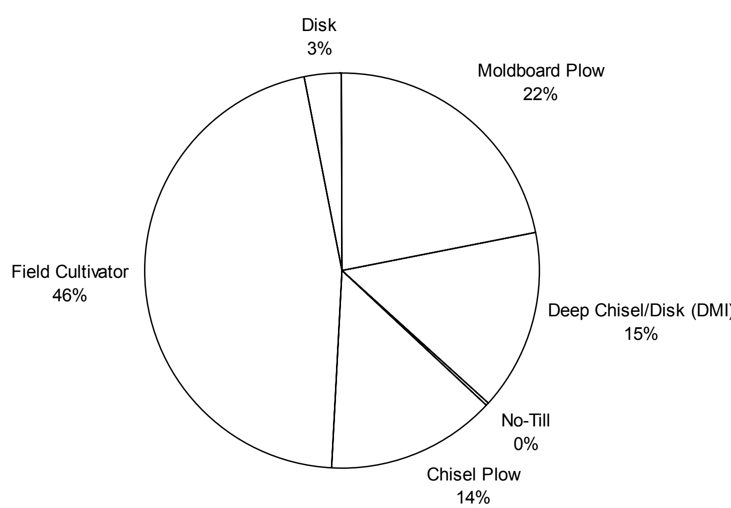

Figure 23. Type of tillage on all corn acres.

Table 11. Tillage Practices on All Corn Acres .

Scenario	All Corn Acres	Percent of Total Corn Acres	Corn Following Soybean Acres	Corn Following Other Crop Acres
Moldboard Plow -- Fall	1,402	22%	240	1,162
Moldboard Plow -- Spring	12	0%	0	12
Deep Chisel/Disk (DMI or Equivalent) -- Fall	946	15%	352	594
Chisel Plow -- Fall	891	14%	580	311
Field Cultivator -- Fall	23	1%	23	0
Field Cultivator -- Spring	2,952	46%	2,952	0
Disk -- Fall	91	1%	43	48
Disk -- Spring	97	1%	0	97
No-Till	11	0%	11	0
All Scenarios Totals and Averages	**6,425**	**100%**	**4,201**	**2,224**

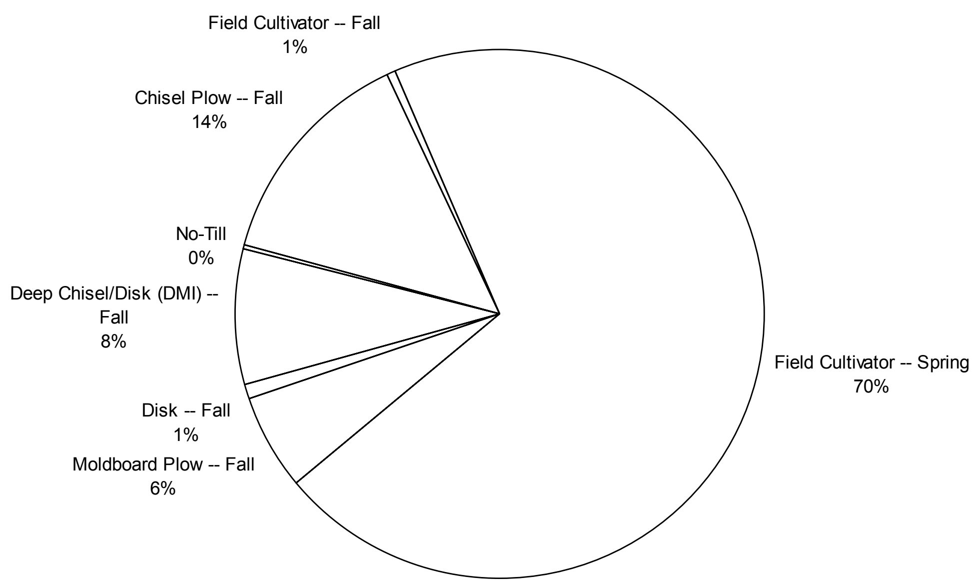

Figure 24. Type of tillage on all corn acres following soybeans. Field cultivation in spring dominated the type of tillage used on corn following soybeans. Fall tillage was completed on 30% of corn acres following soybeans.

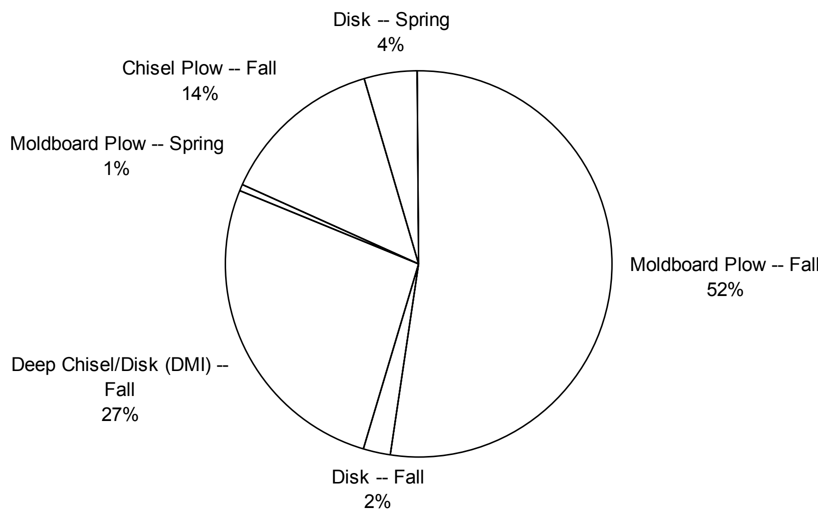

Figure 25. Type of tillage on all corn acres following a crop other than soybeans. Moldboard plow (52%) and deep chisel/disk (DMI or equivalent) (27%) in fall dominated the type of tillage used on corn following a crop other than soybeans. Some fall tillage was done on 95% of corn acres following a crop other than soybeans.

Secondary tillage was also used extensively on all corn acres. Corn acres were generally covered with two tillage passes and often three tillage passes. Corn acres totaled 6,425 acres with 6,414 (99%) acres covered with at least one pass with a tillage implement. Ninety four percent (94%) of all corn acres were covered with at least two passes of a tillage implement and 34% of corn acres were covered with three or more passes of a tillage implement. Secondary tillage passes generally consisted of spring tillage with a field cultivator (86%) (Figure 26). Secondary tillage was done on 91% of all acres of corn following soybeans and 99% of all acres of corn following another crop. Third tillage pass also generally consisted of spring tillage with a field cultivator (86%) (Figure 27). Third pass tillage was done on 15% of all corn acres following soybeans and 72% of all corn acres following another crop. Sixty-nine percent (69%) of corn acres that were initially moldboard plowed eventually had 3 passes from tillage equipment. Eighty-three percent (83%) of corn acres that used a deep chisel/disk eventually had 3 passes from tillage equipment and 13% of soybean acres that used a chisel plow eventually had 3 passes from tillage equipment.

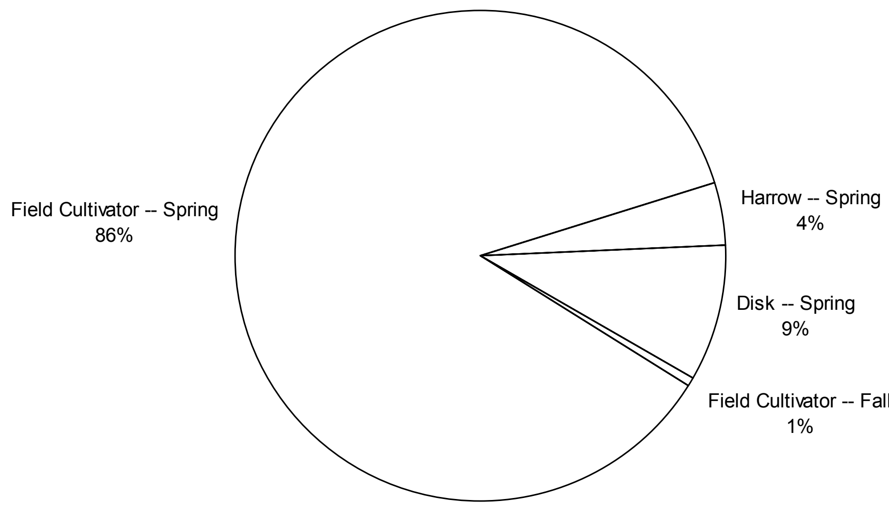

Figure 26. Type of tillage used on all corn acres on second tillage pass.

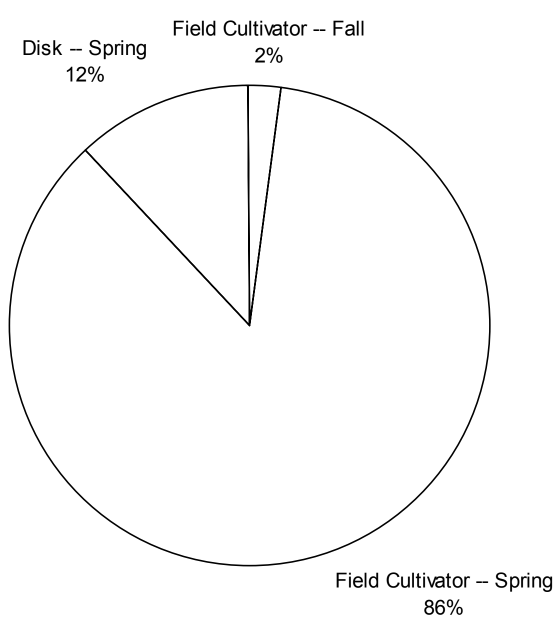

Figure 27. Type of tillage used on all corn acres on third tillage pass.

The most dominant type of primary tillage on soybean acres was the use of a deep chisel/disk or a DMI type of equipment or equivalent. A deep chisel/disk was used on 57% of all acres planted to soybeans (Figure 28). Fall tillage was used on 94% of all acres planted to soybeans. All but 12 acres of soybeans planted were following corn.

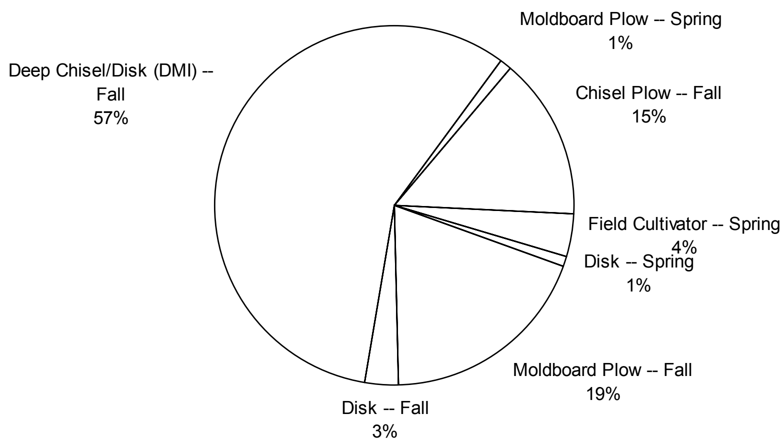

Figure 28. Type of tillage on all acres planted to soybeans.

Secondary tillage was also used extensively on all soybean acres. Soybean acres were generally covered with three tillage passes before planting. Ninety-nine percent (99%) of all soybean acres received at least one pass with a tillage implement. Ninety-eight percent (98%) of all acres planted to soybeans were covered with 2 or more passes from a tillage implement and 81% of acres were covered with 3 or more passes from a tillage implement. Secondary tillage passes generally consisted of spring tillage with a field cultivator (87%) (Figure 29). Third tillage pass also generally consisted of spring tillage with a field cultivator (95%) (Figure 30). Sixty-two percent of soybean acres that were initially moldboard plowed eventually had 3 passes from tillage equipment. Ninety-five percent of soybean acres that used a deep chisel/disk eventually had 3 passes from tillage equipment and 69% of soybean acres that used a chisel plow eventually had 3 passes from tillage equipment.

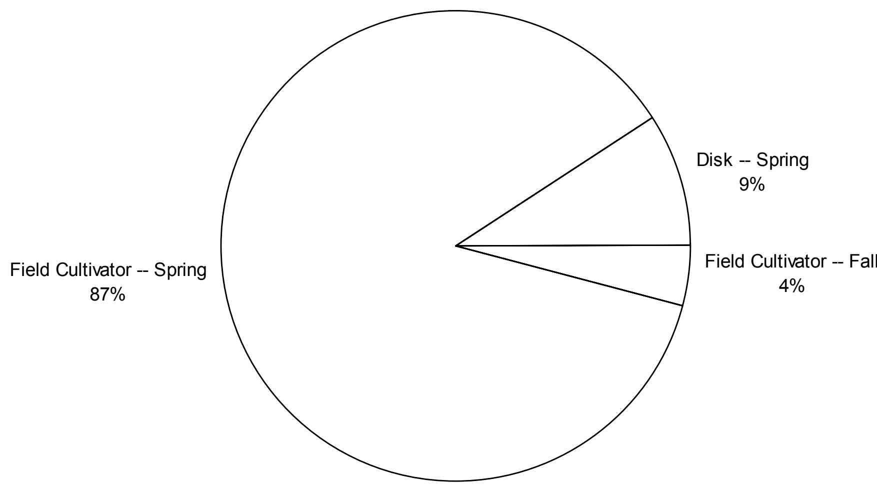

Figure 29. Second pass type of tillage on acres planted to soybeans.

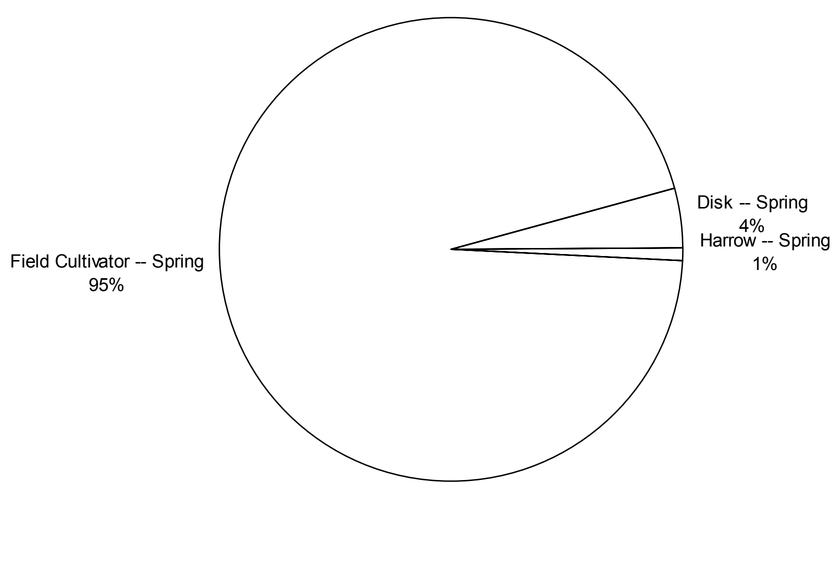

Figure 30. Third pass type of tillage on acres planted to soybeans. All third pass tillage was done in the spring.

Crop residue is highly correlated to the type of tillage performed on the soil. The average percent of residue left on each field was recorded during farm interviews. Most farmers were unaware of how to calculate crop residue. Farm interviews were also conducted in the fall and crop residue information gathered pertained to the amount of crop residue left after planting. If the farmer was unaware of how to determine the amount of crop residue left, explanations were given and examples of what a field may look like with a certain percentage of residue left was shown to the farmer to compare to his fields[24].
Table 12 details the percent of crop residue left on corn and soybean acres after planting.

Table 12. Percent of Residue Remaining at Planting .

Crop	Acres of Crop	Average Percent of Residue Cover	Acres with Residue 0 - 15%		Acres with Residue 15 - 30%		Acres with Residue over 30%	
			Acres	Percent	Acres	Percent	Acres	Percent
Corn Following Soybeans	4,201	12%	2,389	57%	1,801	42%	11	1%
Corn Following Other Crop	2,224	15%	1,833	82%	184	8%	207	10%
Soybeans	4,196	19%	2,054	49%	1,174	28%	968	23%
Total Acres /Average %	**10,621**	**16%**	**6,276**	**59%**	**3,195**	**30%**	**1,186**	**11%**

Percent of slope on each field is also an important factor in preventing sediment and nutrient runoff. Average slopes of fields were also gathered during farm interviews. Figure 31 details the percent slope on corn fields and Figure 32 details the slope on soybean fields.

24 Pictures and systems of different percentages of residue were taken from the Brochure: Crop Residue Systems for Conservation and Profit, U.S. Department of Agriculture, Soil Conservation Service, December, 1992

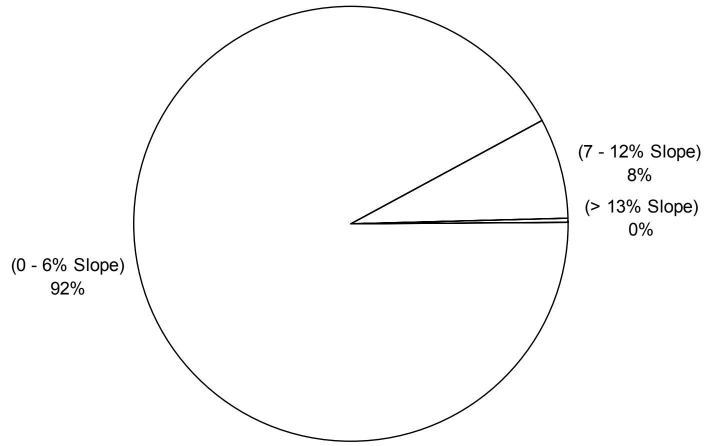

Figure 31. Percent of corn acres falling into 3 different slope categories.

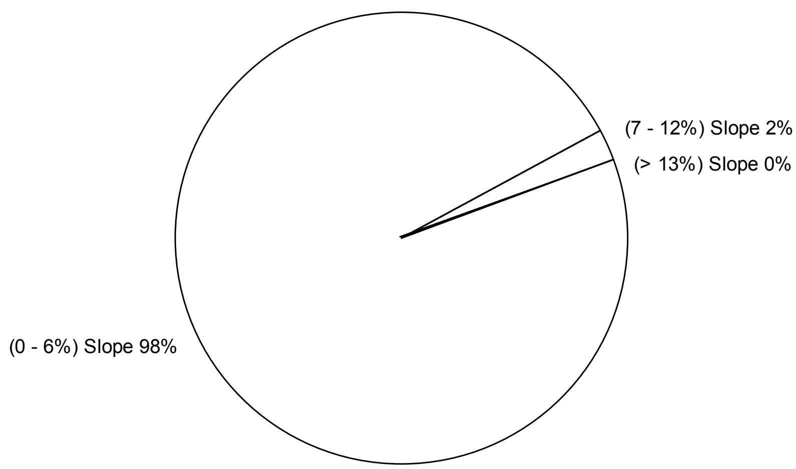

Figure 32. Percent of soybean acres falling into 3 different slope categories.

Corn and soybean acres with slopes greater than 6% averaged 14% residue while corn and soybean acres with slopes 6% or less averaged 16% residue. It appears the farmers in this data set are managing crop residue similar across all acres regardless of slope.

Information was also gathered on conservation management practices used on the individual farms. Farmers were ask if they had any of the following: grass waterways, terraces, contour strips, fields with contour planting[25], permanent pasture, field dams, field wind breaks, or an "other category". Almost all farms had grass waterways and many farms had permanent pasture (Table 13). Many farmers also either had contour planted fields or contour strips, even though less than 10% of cropland was over 6% slope.

Table 13. Conservation Management Practices implemented on the 28 farms.

Management Practice	Number Of Farmers
Grass Waterways	25
Terraces	2
Contour Strips	7
Contour Planting	7
Permanent Pasture	13
Field Dams	4
Wind Breaks	3

Information was also gathered on machinery for residue management. Farmers were asked whether they had any row clearing equipment, coulters on cultivators, or any other type of equipment to manage fields with heavy residue. None of the farmers had any special equipment to manage fields with heavy residue.

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[25] Contour strips are separate narrow fields that cross the slope of a hill while a contour field is one field, generally of row crops, that is planted so the rows cross the slope of hill.

Conclusions and Summary of the Current Nutrient and Tillage Management Practices for the Bevens and Sand Creeks Watersheds

Twenty-eight farms, covering over 14,000 acres, participated in the FArm Nutrient Management Assessment Program (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.

Over 75% of commercial N used on corn was applied as a spring preplant and anhydrous ammonia was the dominant source of N for all applications (80%). Forty-four percent (44%) of the fall-applied anhydrous ammonia was applied before October 29, the average date when the soil temperature does not rise above 50 degrees. Delaying these applications until after October 29 may decrease nitrogen leaching from fall applications.

Manure (first year available) accounted for only 6% of the N while legumes and commercial N accounted for 20% and 74%, respectively. Soybeans was the dominate source of legume N credits. Manure also accounted for 48% of the total P_2O_5 available to 1995 crops with commercial fertilizer supplying 52%. Twenty-six percent (26%) of corn acres received applications of manure leaving ample land available for manure application, if based on N inputs. However, 95% of the acres with soil tests had P_2O_5 levels in the high to very high range leaving few acres where P_2O_5 from manure could be applied and still receive the maximum benefit from the P_2O_5. In this survey there were corn acres available for spreading manure if based on N inputs but limited acres available if based on P inputs, partly due to the high native P levels in the soils.

Storage of manure in manure systems was divided with approximately 50% of the manure stored in liquid systems and 50% of the manure stored as solids. Manure N exceeded crop requirements on 7% of the manured corn acres. On these acres, a reduction in the rate of application of manure and coverage of more acres would increase the value of the retained N from manure in addition to reducing the potential of N leaching.

Only 16% of the farm-generated manure was spread during the winter months. Over 50% of the manure was applied as a broadcast, but not incorporated within 4 days. Incorporation of broadcast manure within 4 days would provide an extra 50% of the N to be available for crop use. Manure testing could improve manure crediting and manure testing was previously done by two of the producers. Approximately half of the livestock producers took advantage of the free manure testing.

On corn acres where no previous manure or legume credits existed to confound the rate selection process of N, producers appeared to be in agreement with recommendations that were made by UM Minnesota Extension Service. Corn acres which were above or below the UM recommendations were equally distributed and the overall average was 3 lbs/acre over the UM recommendations. As manure and legume credits are added to the selection process of determining the correct N rate, producers were not taking enough credits from legumes but were taking nearly the correct amount of credits for manure. On corn acres with no legume credits farmers were reducing N by 42 lb/acre when applying manure and on corn acres with soybean credits farmers were reducing N by 57 lb/acre. Nitrogen credits from the manure averaged 49 and 38 lb/acre, respectively, on each scenario.

Overall, producers **increased** N fertilizer inputs by 12 lb/A on corn following soybeans with no manure applications. Corn following soybean acres accounted for 70% of the excess N in this survey. Reducing the average amount of N applied and accounting for soybean credits could save farmers approximately $10 an acre.

Farmers were crediting N from the 1994 alfalfa crop which was planted to corn in 1995. Farmers reduced N applied by 85 lb/acre. Farmers also reduced N applied by 29 lb/acre for corn acres that were alfalfa in 1993. However farmers were under-estimating manure credits on both of these scenarios. Fertilizer N amounts were the same on corn acres previously in alfalfa in 1994 regardless of manure applications. On average, an additional reduction of 25 lb/N/acre would be possible on corn acres previously in alfalfa.

Soil testing was available for 20% of all crop acres. A much larger percentage of the acres had been recently tested but the tests were not available at the time of the interview. Ninety-five percent (95%) of the tested acres were in the high or very high range for P_2O_5 and 96% of the tested acres were in the high to very high range for K_2O. Farmers reduced P_2O_5 on manured corn acres by 11 lb/A compared to non-manured corn, but manure contributed an additional 73 lb/A of P_2O_5 to manured acres of corn. Application amounts of K_2O were reduced by 54 lb/A but manure contributed an additional 119 lb/A of K_2O to manured acres. Manure would have its greatest value by being applied to corn acres with very low to medium P_2O_5 and K_2O levels and reducing the amounts of P_2O_5 and K_2O in the fertilizer. If acres that were soil tested represent all acres, producers could receive very little replacement value from P_2O_5 and K_2O as most acres are in the high to very high soil test category.

Tillage practices were quite varied across cropland in the survey. On corn acres following soybeans, 70% of the acres were tilled in the spring with a field cultivator. The remaining acres were generally fall-tilled with various implements. No-till acres were extremely minimal. Over 90% of acres were tilled a second time, generally with a field cultivator, and 15% of the acres were tilled a third time, also generally with a field cultivator.

Corn acres following a crop other than soybeans (generally corn or alfalfa) were generally fall-tilled (95%). Tillage equipment used was generally moldboard plow (53%) or deep chisel/disk (27%). Ninety-nine percent (99%) of the acres were tilled a second time and 72% of the acres were tilled a third time. A field cultivator was generally used for both the second and third tillage passes.

Ninety-four percent (94%) of soybean acres were fall-tilled. Deep chisel/disk was used on 57% of the acres while moldboard plow was used on 20% of the acres. Ninety-eight percent (98%) of soybean acres were tilled a second time and 81% of the acres were tilled a third time. A field cultivator was used on 86% on the acres on the second tillage pass and 86% of the acres receiving a third tillage pass. Using a tillage strategy that results in a 30% crop residue cover could reduce gross field erosion by 50%, when compared to a tillage strategy with no crop residue.

Limited amounts of crop residue left may be a result of most acres receiving two or three passes with a major tillage implement in addition to the type of implement used. Eleven percent (11%) of corn and soybeans acres were left with over 30% crop residue cover. Thirty percent (30%) of corn and soybeans acres were left with a crop residue cover of between 15% and 30% while 59% of acres were left with a crop residue cover of less than 15%. Overall all corn and soybean acres were left with an average of 16% crop residue.

Most cropland (over 90%) had slopes of less than 6%. Fields with slopes greater than 6% were tilled similar to fields with slopes of 6% or less. Contour strips or contour fields were used by about one-fourth of the farmers in the survey. Grass waterways were on 25 farms and 13 farms had some type of permanent pasture.

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. Soybeans crediting is an area where there is a strong need for more education in this study area. Additional research may also be needed on the deep chisel/disk type tillage equipment to develop recommendations for depth and speed of use for maximum residue left and amount of additional tillage needed. 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 legume inputs. In this survey it appears farmers are taking approximately the correct amount of N credits for manure and also alfalfa except when manure and alfalfa credits are combined on the same acres.