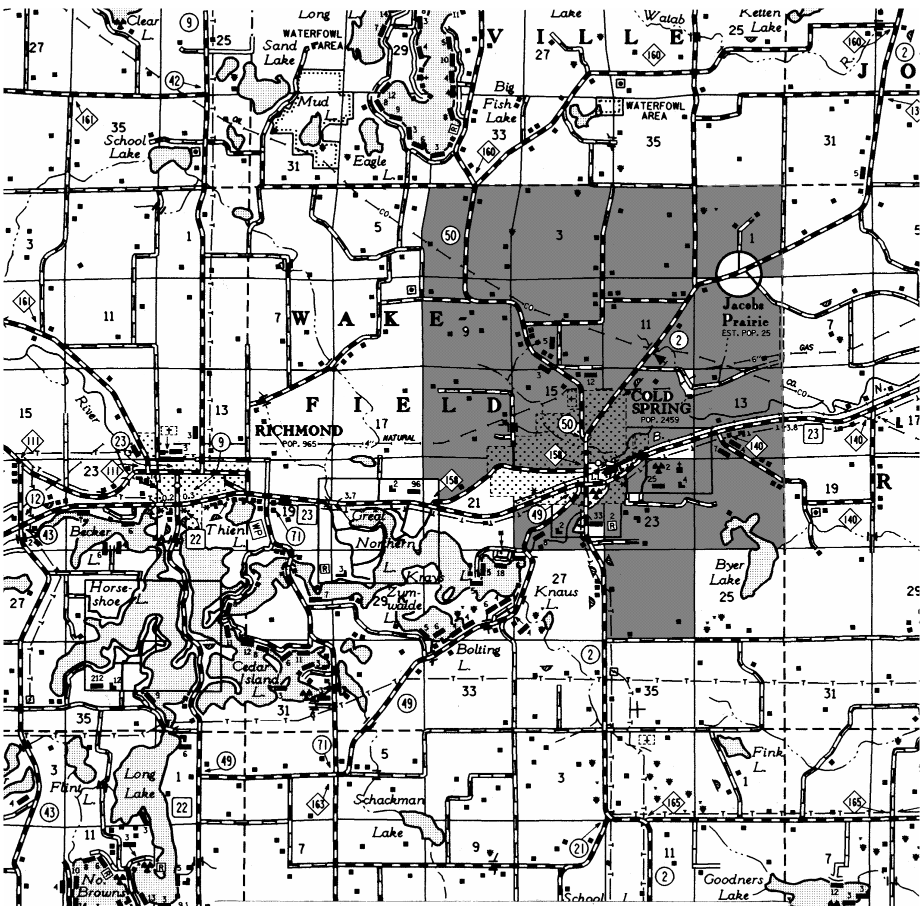
Survey of Farmers

Within the

Cold Spring Wellhead Protection Area



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General information:
Farmers in the Cold Spring Wellhead Protection Area

Water quality in the Cold Spring Wellhead Protection Area (CS-WPA) is a concern due to the health risk associated with elevated nitrates in drinking water. The CS-WPA includes six water suppliers considered "public" by the Minnesota Department of Health (MDH): the city of Cold Spring wells, Cold Spring Granite Company, Glick Brewery, Cold Spring Alano, Gold'n Plump, and the Towns Edge Mobile Home Park. Cold Spring has four city wells ranging in depth from 60 to 98 feet. Concentrations of NO_3-N (Nitrate) vary from less than 1 to 8 ppm across all public water suppliers in the CS-WPA. The newest well for the city of Cold Spring became operational in 1999 and currently has a nitrate level between 3 and 4 ppm. The wellhead protection area is defined by the MDH and includes the area where city of Cold Spring wells and the wells serving the additional businesses and mobile home park could be affected by contamination from surface and subsurface activities. This study focuses on the farming activities associated with the wellhead protection area and reports the results of farm surveys conducted throughout the CS-WPA as initially defined in 1998.

A list of farmers in the CS-WPA was obtained from the Stearns County Farm Service Agency. Local Soil and Water Conservation District personnel, Minnesota Extension Service educators, and Natural Resources Conservation Service personnel were contacted in January 1998 to inform them of the specifics of the proposed farm surveys and overall project goals. The SWCD, NRCS and MES served as important links between the farmers and the MDA staff. An MDA letter – signed by the Commissioner – was sent to each farmer and local agency staff made personal telephone calls to farmers as a follow-up. The letter's intent was to identify: 1) the overall project, 2) the purpose of the nutrient assessment and why they were selected: 3) and what types of information and amount of time would be necessary to successfully complete the project. Letters were sent to 45 farmers and a total of 19 farmers were interviewed. Approximately 40% of the farmland in the CS-WPA was included in the survey.

The Minnesota Department of Agriculture developed the Farm Nutrient Management Assessment Program (FANMAP) approximately 7 years ago. FANMAP is a data gathering tool and analysis system that provides a thorough understanding of current farm practices regarding agricultural inputs. This information is used to design effective water quality educational programs and provides baseline data to determine program effectiveness over time. In the past seven years, over 500 farmers throughout Minnesota have volunteered two to four hours of their time to share information about their farming operations. Previous FANMAP surveys have been conducted as a result of funding through the Legislative Commission on Minnesota Resources or Clean Water Partnership programs.

Nutrient Information of the Selected Farms in Cold Spring Wellhead Protection Area

Inventory forms and database design were patterned after a previous successful project[1]. 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 surveyed farm acres within the CS-WPA.** Soil and manure testing results were also collected if available. Nutrient inputs, and yields, were specific for the 1998 cropping season. Crop types and manure applications (starting in the fall of 1997) were also collected from the 1997 season for purposes of 1998 nitrogen crediting. Long-term yield data generally reflected the past three to five years. Livestock census and other specifics for the entire farm (i.e. types of manure storage systems, total farm sizes) were also recorded. Information was gathered from the farmer or the fertilizer dealer if the dealer kept the farmer's records.

Farm Size, Crop and Livestock Characteristics of the Selected Farms in Cold Spring Wellhead Protection Area

Nineteen farmers were interviewed in January through March of 1999. Some of the "farmers" were actually a combination of farmers such as a father and son who farmed together. Fifteen of the 19 farmers applied some type of manure to cropland acres.

A total of 3,263 acres of farmland were inventoried in the CS-WPA study. Farm interviews covered approximately 40% of all agricultural acres in the watershed. Livestock appeared to play a prominent role in the CS-WPA for the 1998 growing season.

Table 1 provides a listing of each type of crop grown and the corresponding acres. Irrigated agriculture plays an important role, accounting for 27% of the surveyed acres.

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

Table 1. Crop Type and Acres in the CS-WPA. (Numbers Based on 19 Participating Farms)			
Crop	Total Acres	Irrigated Acres	Non-irrigated Acres
Corn	1,873	615	1,258
Soybeans	149	56	93
Alfalfa	630	222	408
Small Grain	63	0	63
Pasture/Grasses	291	0	291
CRP	61	0	61
Other	196	0	196
Total Acres	3,263	893	2,370

Commercial Fertilizer Use Characteristics on Selected Farms: Cold Spring Wellhead Protection Area:

Field corn accounted for 98% of the 173,000 pounds of N commercial fertilizer use on the surveyed farms. All corn acreage received commercial N fertilizer (Table 2). Average fertilizer N rate on corn acres with commercial fertilizer was 91 lb/A. This rate is calculated as the mean 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.

Table 2. Distribution Of Commercial Nitrogen Applications On Cropland - 1998.			
Crop	**Acres Receiving N Fertilizer**	**Total N Applied**	**Average Rate of N on Fertilized Acres**
Non-Irrigated Corn	1,258	98,028	78
Irrigated Corn	615	72,966	119
Alfalfa	91	2,044	22
Small Grains	16	525	32
Soybeans	31	248	8
TOTALS	**1,993**	**173,812**	**-----**

Most of the soils within the CS-WPA are moderately coarse and coarse, with sandy loams and loams being the dominating types. Irrigation is common on these soils and irrigated corn acres accounted for 73,000 pounds of N or 42% of all N used. Twenty-seven percent of crop acres were irrigated. Thirty-three percent of the corn acres were irrigated. Average rate of commercial nitrogen on irrigated and non-irrigated corn was 119 and 78 lb/A. respectively.

The 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 Central Minnesota and irrigated soils[2]. There was no fall application of N for any of the crops. Approximately 59% of commercial nitrogen fertilizer was applied as a sidedress on all corn acres (Figure 1).

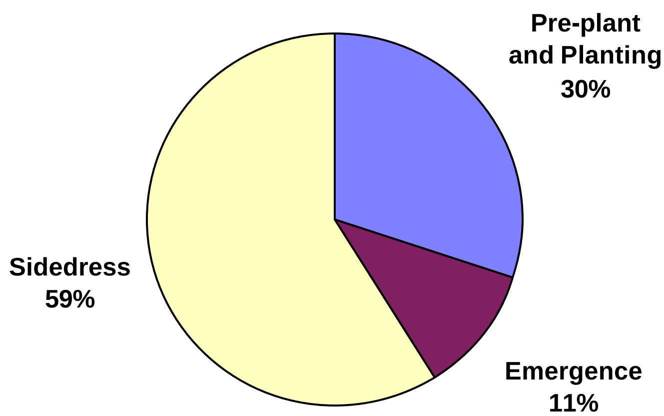


Figure 1. Timing of N fertilizer applications across all corn acres. There was no fall application of N.

Best management practices for nitrogen use on corn in Central Minnesota include a variety of recommendations specific for the soils in central Minnesota. Best management practices include: 1) *do not apply fertilizer nitrogen in the fall to coarse-textured or sandy soils*. Farmers in the CS-WPA did not fall-apply nitrogen; 2), *a sidedress or split application is preferred*. Fifty-nine percent of the nitrogen was applied as a sidedress; 3) *spring application of anhydrous ammonia or urea is encouraged*. Farmers also followed this recommendation; and 4) *inject or incorporate sidedress applications of urea and Urea Ammonium Nitrate (UAN) to a minimum depth of 4 inches*. Urea ammonium nitrate is an important N source accounting for 43% of commercial N inputs. Fifty-eight percent of the UAN was broadcast as a sidedress without incorporation. Incorporation would minimize N losses through volatilization. Table 3 details the timing of corn fertilized with commercial N.

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

The University of Minnesota also recommends a small amount of N in the starter fertilizer on irrigated corn. Twenty-three percent (23%) of the irrigated corn acres received starter N applications of more than 75 lbs/A, although this practice was limited to a small number of farms.

Table 3. Timing of N Fertilizer Applications on All Corn Acres.

Crop	Growth Stage	Total N Applied	Percentage of Total N for Each Crop
Corn	Spring Plant/Preplant	51,329	30%
Corn	Emergence	19,140	11%
Corn	Sidedress	100,526	59%
	TOTALS	**170,995**	**100%**

Urea and UAN solutions contributed 29% and 43% of the nitrogen on corn in the CS-WPA (Figure 2). In other parts of Minnesota anhydrous ammonia accounts for 60% to 80% of the commercial N applied to corn. Urea and UAN solutions are more prone to leaching losses.

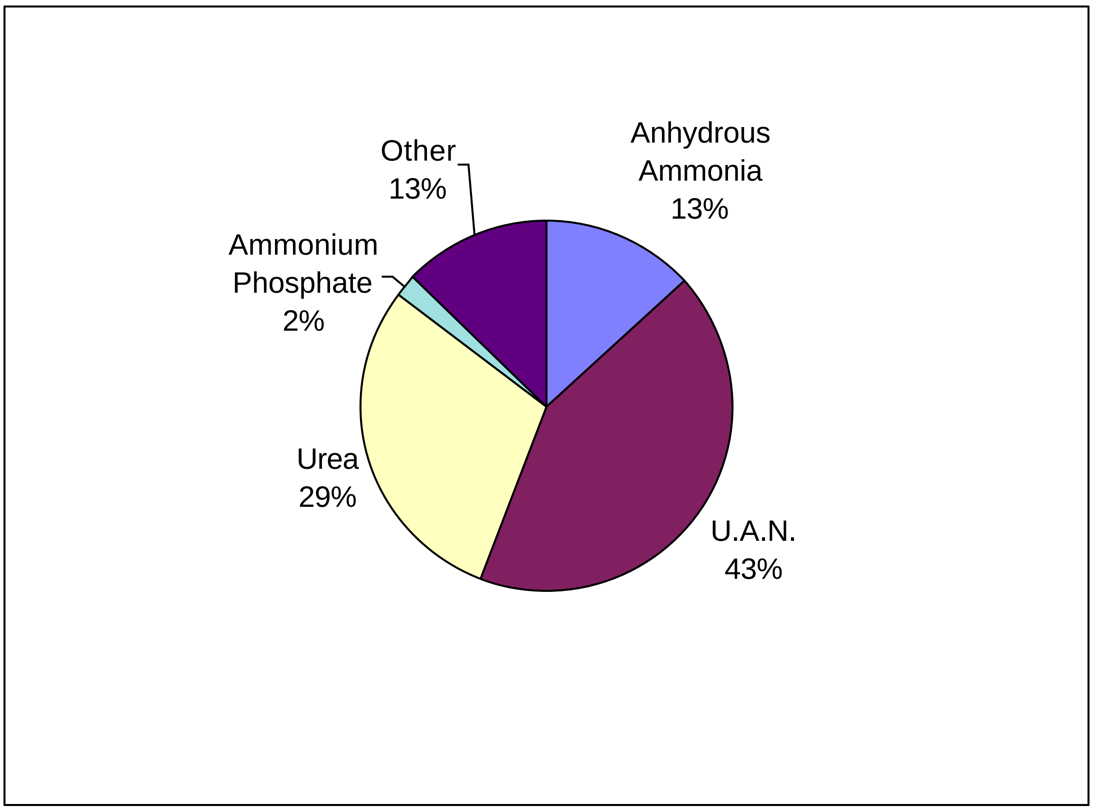


Figure 2. Sources of commercial N used on all corn within the CS-WPA.

Livestock and Manure Characteristics of the Selected Farms in Cold Spring Wellhead Protection Area

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 4 includes a complete animal inventory, including estimates of N, P_2O_5 and K_2O produced[3] and collected in various types of manure systems for spreading on acres in the survey. Additionally, when cattle spend time in pastures and in large lots where manure is not collected, the manure generated is not considered in the collected amounts. Livestock numbers represent the livestock on hand from the fall of 1997 to the summer of 1998. These livestock inventories would contribute manure to the 1998 crops. Fifteen of the nineteen farmers had livestock within the CS-WPA.

Table 4. 1998 livestock numbers, and manure N, P_2O_5 and K_20 produced and collected by livestock types in sample population. (Numbers based on 15 farms.)

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		Pounds		Pounds	
Dairy Bulls	8	1,736	1,700	704	689	1,400	1,371
Dairy Cows	515	111,755	108,500	45,320	44,000	90,125	87,500
Dairy Calves	316	24,648	22,191	10,428	9,389	19,592	17,639
Replacement Heifers	219	33,945	29,579	13,578	11,832	27,156	23,663
Dairy Steers	154	23,870	23,870	9,548	9,548	19,096	19,096
Sows/Boars	28	749	749	519	519	519	519
Slaughter Hogs	2,212	18,688	18,688	13,337	13,337	14,399	14,399
Beef Cows/Bulls	84	11,056	7,703	8,426	5,869	9,626	6,706
Beef Feeders Under a Year	68	4,216	2,635	3,196	1,998	3,740	2,338
Beef Feeders Over a Year	549	52,155	33,115	37,881	24,052	43,920	27,887
TOTALS	**4,153**	**282,818**	**248,730**	**142,937**	**121,233**	**229,573**	**201,118**

Manure collection varied by type of livestock in the CS-WPA. Dairy manure supplied 69% of the total amount of N collected from all livestock raised on the farm (Figure 3).

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

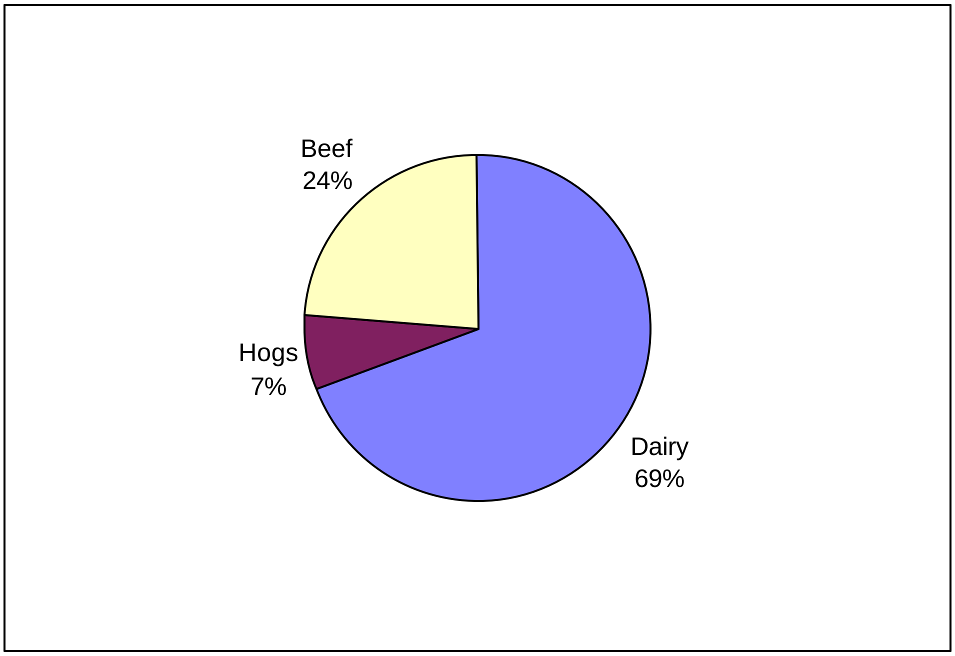


Figure 3. Amounts of manure nitrogen (total) generated by all animal types across all selected farms.

The type of storage system 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. Fifteen farms produced or applied manure. Of these, five applied some liquid manure while the other ten applied only solid manure.

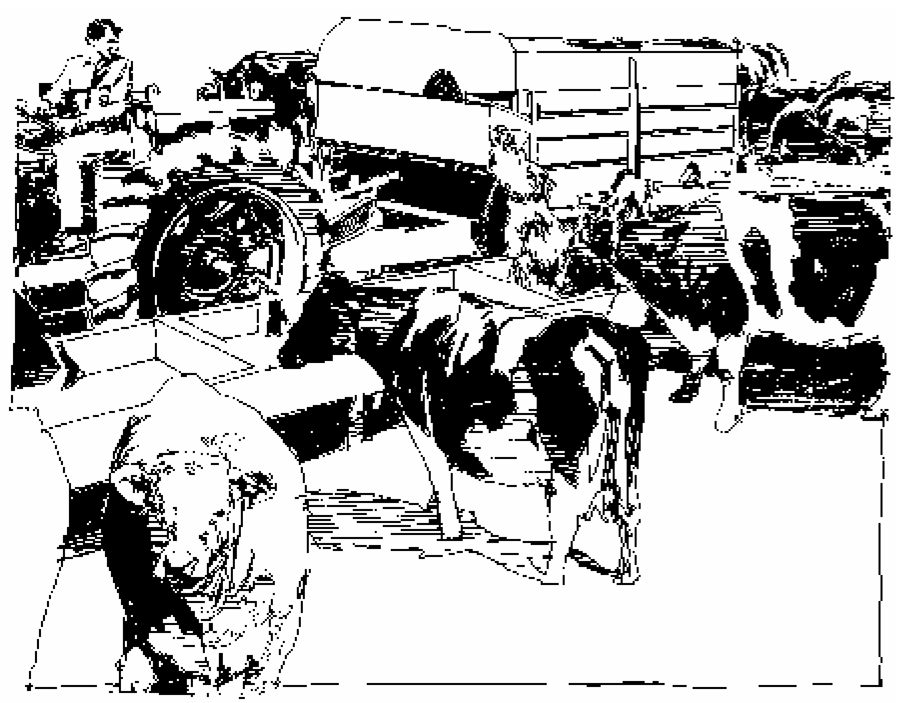
Nutrient losses from collection and storage were estimated from accepted guidelines[4] for each individual storage system. Losses as a function of application methods and timing factors were calculated on a field-by-field basis. Most solid manure systems were cleaned on an "as needed" basis, both in the barns and lots. Liquid systems were generally cleaned in the fall. There was a total of 37 different manure "systems" on the 15 livestock farms. For example, one farm had several systems for collecting manure, such as, a pit and a farrowing barn for hogs and a deep bed barn for cattle.

Amounts of N and P_2O_5 collected, lost in storage, and amounts retained for land application are summarized by collection systems in Table 5.

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

Table 5. Manure N, P_2O_5 and K_2O collected and storage losses by all livestock on all farms in 1998. (Numbers based on 15 farms.)								
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		Pounds		Pounds	
Solid Manure	31	165,075	107,066	82,581	66,065	134,240	107,392
Liquid Manure	6	83,655	62,069	38,652	30,922	66,878	53,502
TOTALS	**37**	**248,730**	**169,134**	**121,233**	**96,986**	**201,118**	**160,894**

The fate of manure-N is summarized in a simple flow diagram (Figure 4). This diagram simplifies the complexities associated with N from excretion to "plant available". Due to the large amount of pasture and small amount of incorporation of solid manure (the majority of manure is dairy), only 29% of the total amount of N collected was available for the first-year credit to the crop.



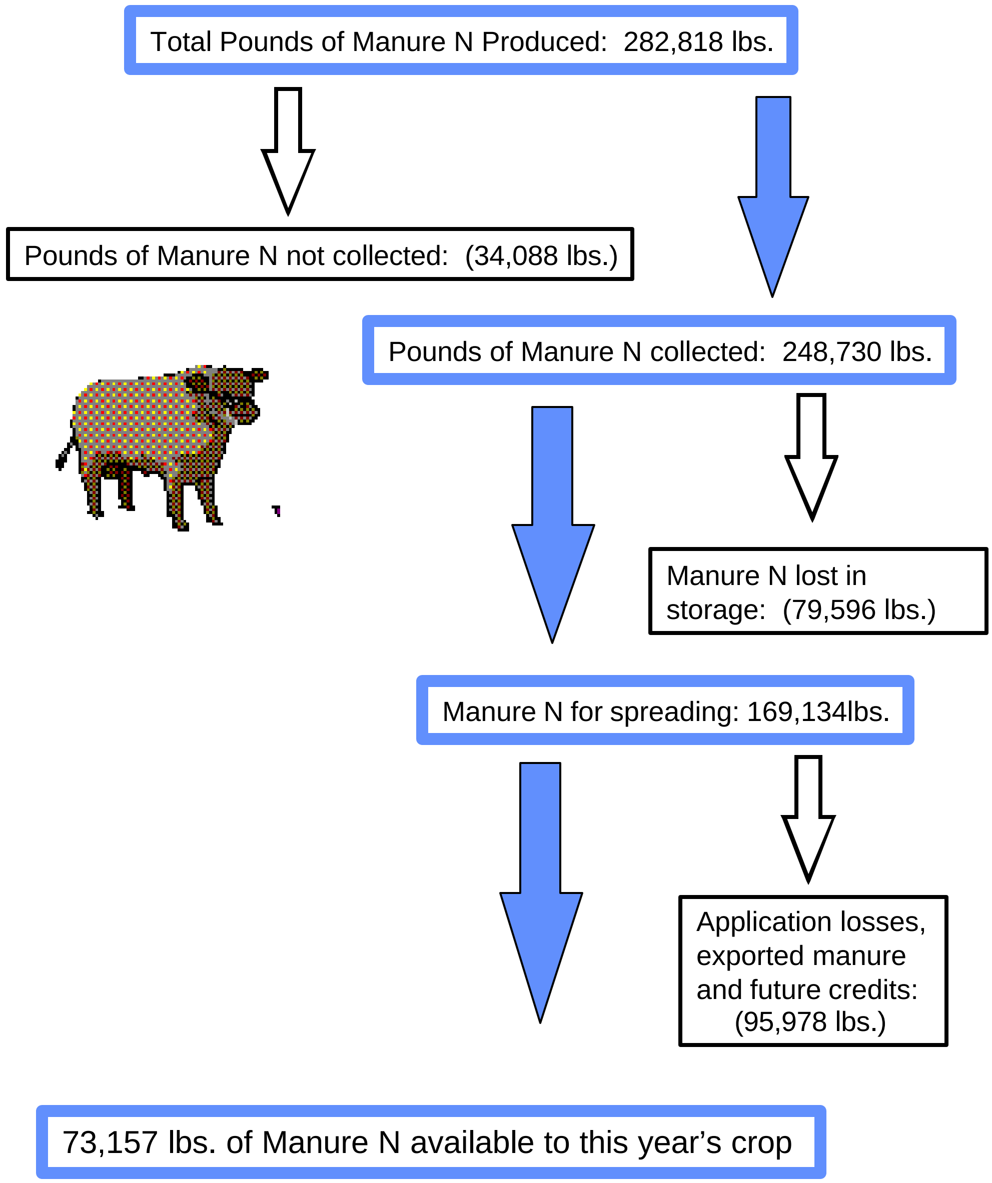


Figure 4. Fate of farm generated and imported manure-N across all storage and management factors. Twenty-nine percent of manure N collected was available to the crops in 1998 as first year N.

A total of 73,000 lbs. of manure N was available to all crops. Manure supplied 61,000 lbs. of N to the 1998 corn crop and 12,000 lbs. of N was supplied to other crops. Thirty-nine percent (39%) of the farm-generated manure on corn acres was applied as a broadcast with no incorporation and 61% of the manure was incorporated within 4 days or injected (Figure 5). Incorporation of broadcast manure within 4 days or less would generally double the amount of retained N available for crop use.

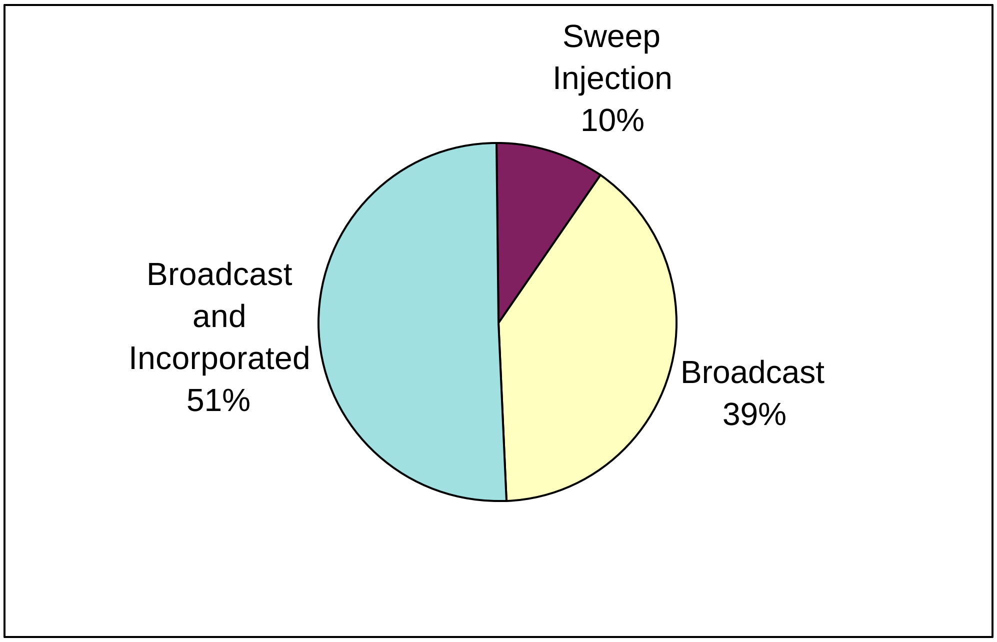


Figure 5. Type and percentage of manure application for corn acres.

Six percent of all available N in collected manure was winter-applied, whereas 58% was fall-applied (Figure 6). Fall applications of manure on coarse-textured soils are believed to have negative environmental impacts, though more research is needed on this topic.

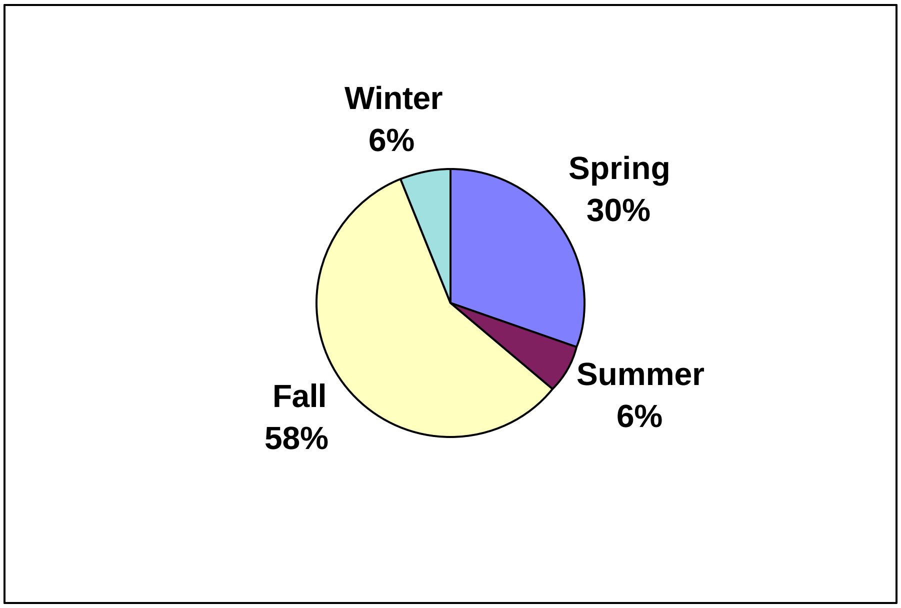


Figure 6. Timing of manure applications on corn acres based on manure N availability.

Relative Importance of N Sources on the Selected Farms: Cold Spring Wellhead Protection Area:

The University of Minnesota recommends that legume crops be credited for their N contributions to subsequent crops. Alfalfa grown in the CS-WPA was assumed to have 2-3 plants per square foot when tilled for the following corn crop. First year alfalfa, therefore, provided a 75 lb/A credit, and second year alfalfa provided a 50 lb/A credit. Soybean credits would average 40 lb/A. In the Cold Spring survey, alfalfa was by far the most important source of legume N, supplying approximately 88% of all legume N.

Commercial fertilizers (65%), manures (24%), and legumes (11%) contributed a total of 260,000 pounds of "first year available N" to all corn acres (Figure 7). Proper crediting of these sources is critical in maintaining economic and environmental balances. Corn rotations were dominated by corn following corn with 71% of corn acres planted on acres that were corn in 1997. Only 24% of corn acres received legume credits from past cropping history.

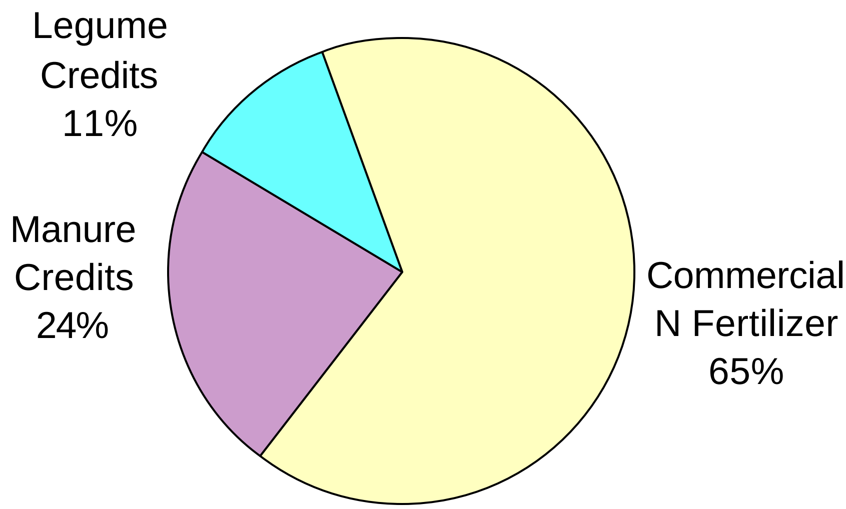


Figure 7. Relative N contributions from fertilizers, manures and legumes across all corn acres. N inputs totaled 260,000 for all sources across the 19 participating farms.

Nitrogen Balances and Economic Considerations: Cold Spring Wellhead Protection Area

Contributions of commercial N to corn totaled 171,000 pounds and manure supplied 61,000 lbs. of N. Irrigated corn received 107,000 lbs. of N and non-irrigated corn received 125,000 lbs. of N. The irrigated corn yield goal across all farms averaged 170 Bu/A, whereas historic yields averaged 162 Bu/A. The non-irrigated corn yield goal averaged 122 Bu/A, whereas historic yields averaged 116 Bu/A. Yield goals for both irrigated and non-irrigated corn was equal to or slightly greater than historic yields. It appears farmers are using realistic yield goals for both irrigated and non-irrigated corn acres.

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. Irrigated acres use UM recommendations for soils in the low organic matter category and the soils in the non-irrigated corn fields were generally low in organic matter. For this survey all soils were assumed to be low in organic matter.

University of Minnesota (UM) nitrogen recommendations for irrigated corn averaged 182 lb/N/A (Figure 8). Actual amounts of N applied from fertilizer and manure averaged 174 lb/A across all irrigated corn acres. Factoring in all appropriate credits from fertilizer, legumes and manures, there was an under-application rate of 8 lb/N/A. University of Minnesota (UM) N recommendations for non-irrigated corn averaged 114 lb/N/A (Figure 9). Actual amounts of N applied from fertilizer and manure averaged 100 lb/A respectively across all non-irrigated corn acres. Factoring in all appropriate credits from fertilizer, legumes and manures, there was an under-application rate of 14 lb/N/A.

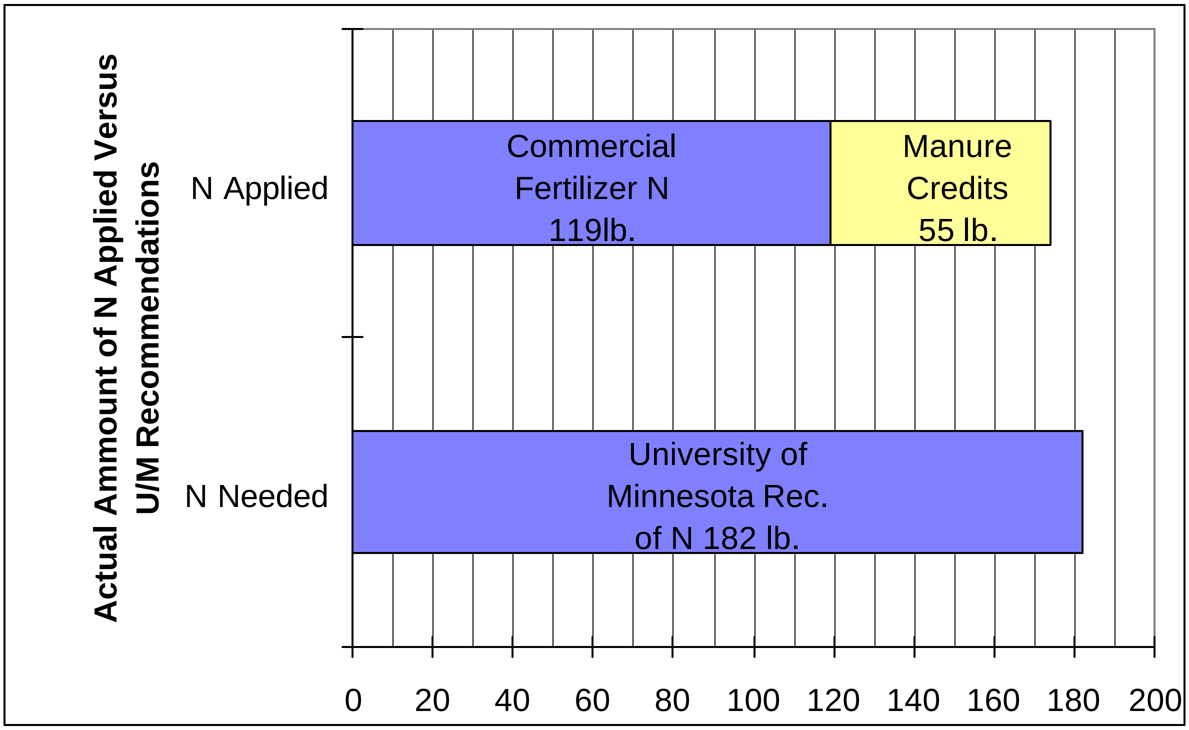


Figure 8. Crop N requirements based on UM recommendations in comparison to actual N inputs (fertilizer, and manure) across all irrigated corn acres. Total corn area in this analysis was 615 acres.

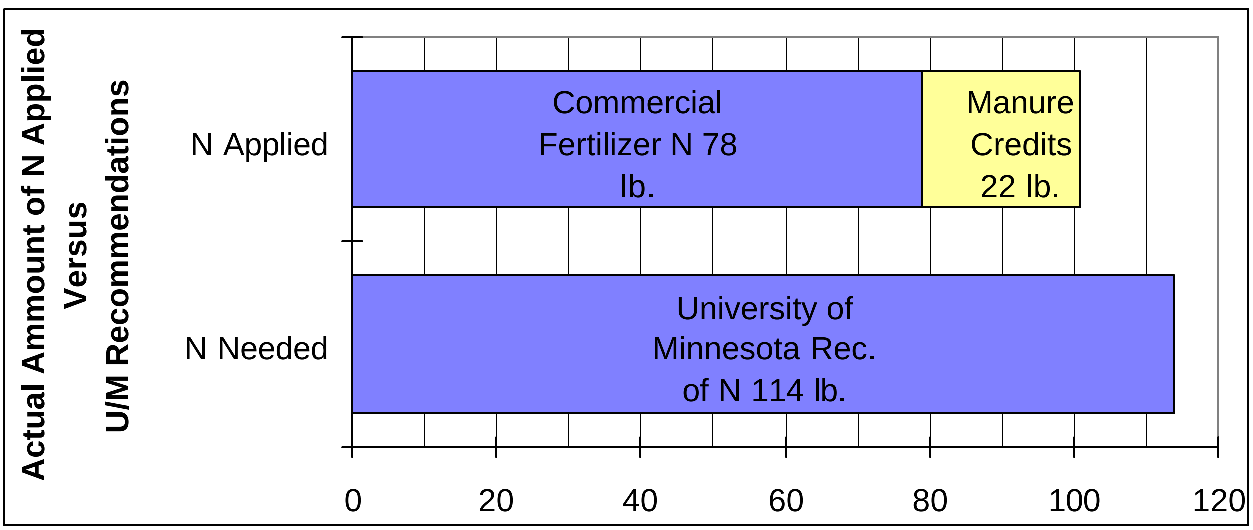


Figure 9. Crop N requirements based on UM recommendations in comparison to actual N inputs (fertilizer, and manure) across all non-irrigated corn acres. Total corn area in this analysis was 1,258 acres.

Factoring in legume N credits and manure N credits into the process on a field-by-field basis, the amounts in shortages/excess of 1998 UM recommendations are illustrated in

Figure 10. 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 improvements in water quality can be obtained through focused educational programs.

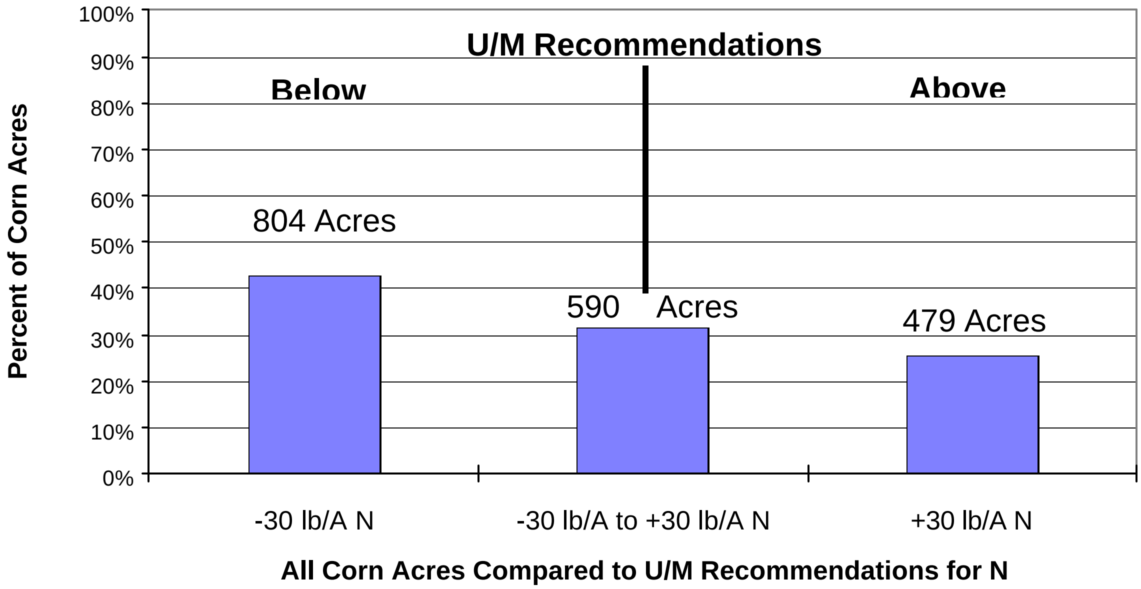


Figure 10. Distribution of corn acres that fell within plus and minus 30 pounds of the UM recommendations for N.

Twenty-six percent (26%) of the corn acres were classified as being 30 lb/A or more in excess of UM N recommendations and 43% of the acres were 30 lb/A or more below UM category. By adjusting both of these categories to within 30 lbs of the UM recommendations, N applied to corn acres would actually increase by 23,000 lbs. It appears farmers are very close to recommended N rates on corn.

Corn acres receiving N credits from legumes accounted for 24% of all corn acres. However, corn acres receiving legume N credits accounted for 61% of all corn acres where N was applied at rates greater than UM recommendations by 30 lbs/A or more. Figure 11 details the percentage of corn acres over-applied with N by crop history. Fourteen percent of corn acres following corn were over-applied with N. Sixty-seven percent of corn acres following alfalfa were over-applied with N.

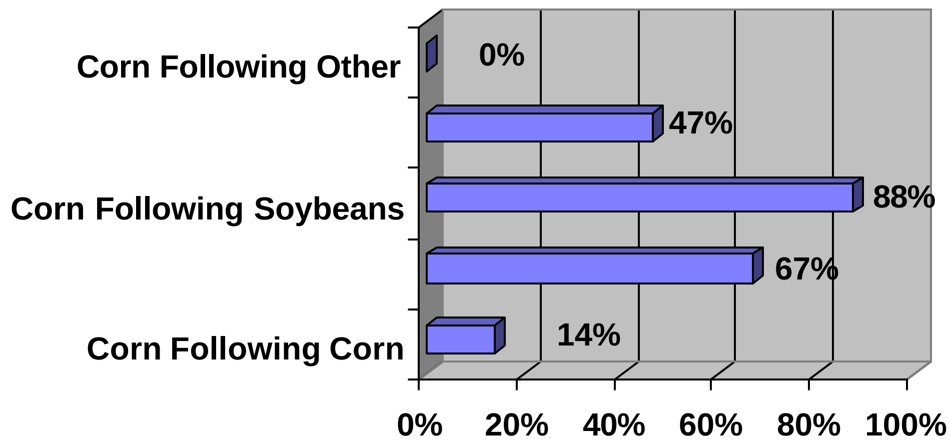


Figure 11. Percent of corn acres where N was over-applied based on crop history. Corn acres with legume credits accounted for 24% of all corn acres and accounted for 61% of the acres with excess N.

Corn acres receiving N credits from liquid manure accounted for 21% of all corn acres. However, corn acres receiving N credits from liquid manure accounted for 38% of all corn acres where N was applied a rates greater than UM recommendations by 30 lbs/A or more. Figure 12 details the percentage of corn acres over-applied with N by manure applications.

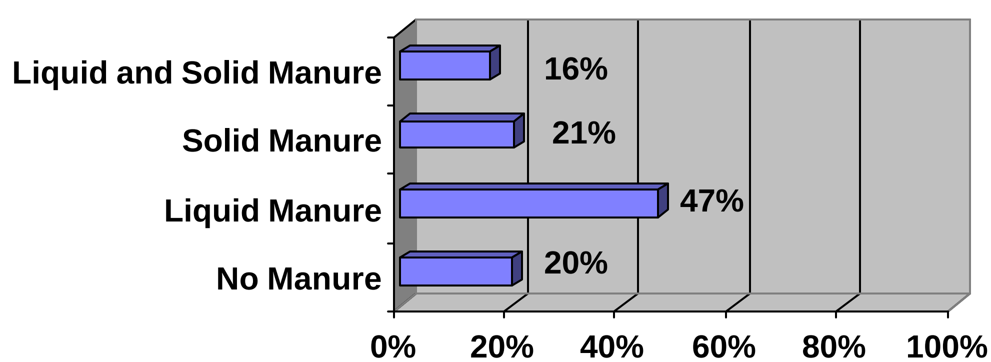


Figure 12. Percent of corn acres over-applied with N based on manure applications.

A total of 479 acres of corn were over-applied with N by more than 30 lbs/A. All of these acres received either manure or legume credits. Figure 13 details the percentage of corn acres where N was over-applied based on manure applications and legume credits.

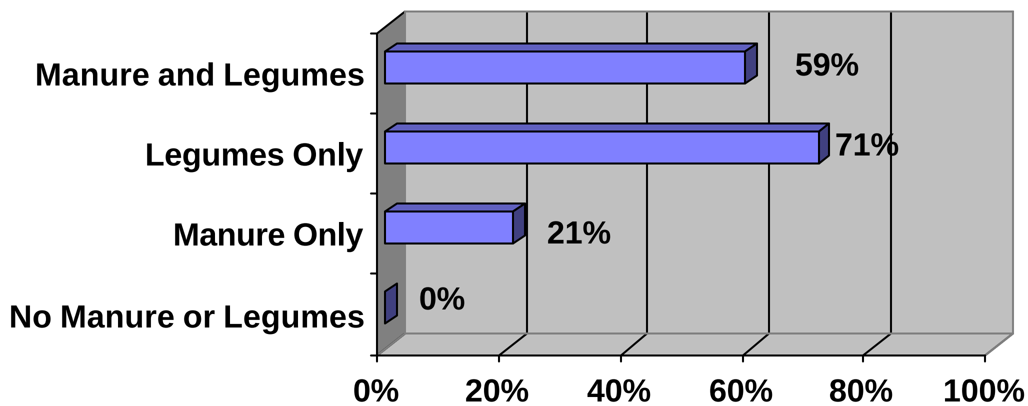


Figure 13. Percent of corn acres over-applied with N by manure applications and legume credits. A total of 479 acres were over-applied with N.

Conclusions and Summary of the Current Nutrient Management Practices for the Cold Spring Wellhead Protection Area.

Nineteen farms, covering 3,263 acres, participated in the FArm Nutrient Management Assessment Program (FANMAP) with staff from the Minnesota Department of Agriculture. Producers volunteered two to four hours of their time to share information about their farming operations. The overall purpose of the program was to develop a clear understanding of current farm practices regarding agricultural nutrients and to utilize this knowledge for future water quality educational programs.

Ninety-eight percent of the commercial N applied on selected farms within the CS-WPA was applied to corn acres. Manure (first year available) accounted for 24% of the N while legumes and commercial N accounted for 11% and 65%, respectively. Alfalfa was the dominant source of legume N credits. Irrigated agriculture accounted for 27% of land use and 42% of the N applied.

Farms averages for N use were 174 lbs/A for irrigated corn and 114 lbs/A for non-irrigated corn. On average, irrigated corn and non-irrigated corn were under-applied with N by 9 lbs/A and 14/lbs/A respectively when compared to UM recommendations for N. Only 25% of the farmers were over-applying N on corn in the CS-WPA.

Anhydrous ammonia was not a source of N and no fall application of N occurred. It appears some improvements in management could be made in regard to sidedress applications of UAN on corn. Incorporation of N would benefit the farmer and decrease N losses. However, if farmers are applying pesticides, it will require an extra pass through the field. A limited amount of starter, less than 30 lbs, would decrease the potential for leaching of N.

Over-application of N occurred on over 50% of corn acres when legume credits or when legume and manure credits were included. In contrast, when no legume/manure credits or only manure credits were involved, between 0% and 21% of the corn acres were over-applied with N. Increasing legume crediting and to a lesser degree, manure crediting would benefit the farmer and decrease the chance of N losses.

Fall application of manure could be a concern if applied early before the soil temperature decreases to near fifty degrees. Delaying manure applications until late fall would increase manure N availability to the corn crop and decrease N leaching. Producers could also increase manure N credits available for crop use by incorporation of manure within 4 days of application.

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 UM. It is also evident that promotional activities need to continue and be specifically targeted to specific practices.