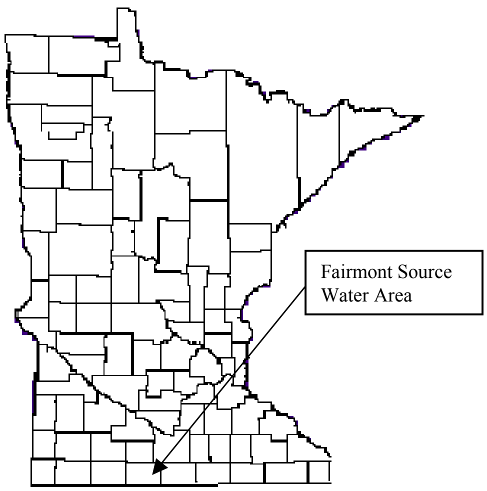
1999 Nutrient Management Assessment of Agricultural Practices in the Dutch Creek and South Chain of Lakes Watersheds, Fairmont, MN



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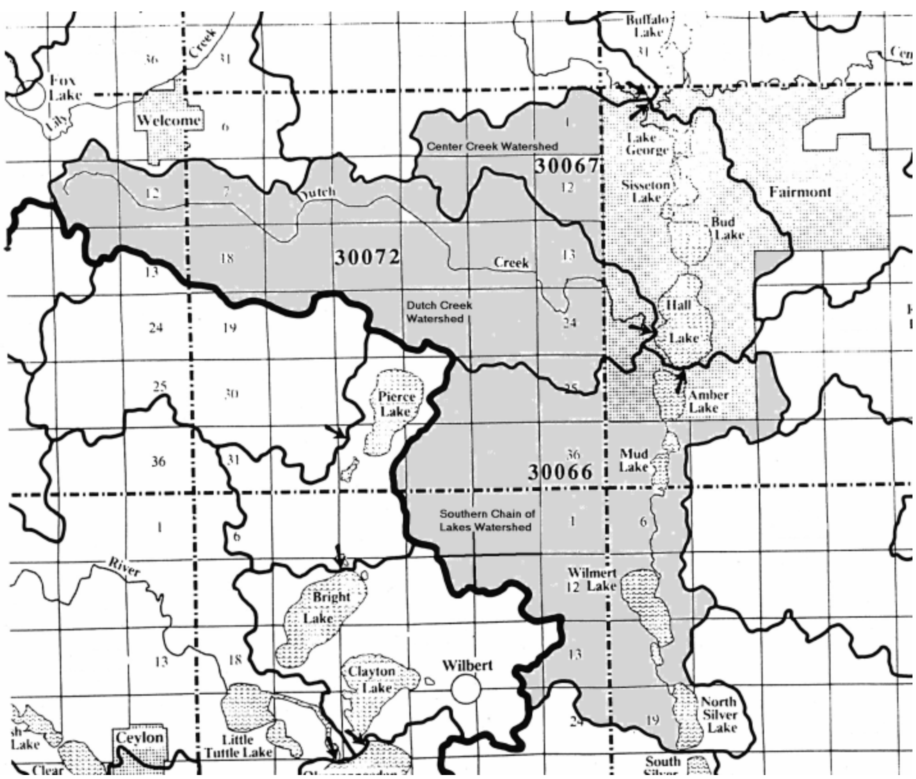


General information:
Farmers in the Fairmont Source Water Area.

The city of Fairmont is unique because it is one of the few small Minnesota communities that obtains its drinking water from surface water supplies. Fairmont draws its water from Bud Lake which is one of seven lakes that makes up the Chain of Lakes. This poses some unique problems. Elevated nutrients, particularly phosphorus and nitrogen cause the large algae blooms. Treatment is expensive and the high amounts of chlorination creates concerns with trihalomethane formation. The Source Water Protection Area SWPA boundaries were established by the Minnesota Department of Health (MDH) and encompass an area where the source of drinking water could be affected by contamination from man's activities. The Fairmont Chain of Lakes drain an area of 265,500 acres, of which 85% is agricultural land. This study focuses on the farming activities associated with the Fairmont Source Water Area (F-SWA) and reports the results of farm assessments conducted throughout the F-SWA for the 1999 cropping season.

A list of farmers/operators in the F-SWA was obtained from the Martin County Farm Service Agency. Minnesota Extension Service Educators, City of Fairmont, Martin County Environmental Service Office, Fairmont Lakes Foundation, Natural Resources Conservation Service (NRCS) personnel and the Soil and Water Conservation District (SWCD) personnel were contacted to inform them of the specifics of the project and overall goals. These were all members of the Fairmont Source Water Protection group. Introduction letters describing the project were mailed to the farmers in December of 1999. The letter's intent was to identify: 1) the overall project; 2) the purpose of the nutrient assessment; 3) why individual farmers were selected, and; 4) what types of information and amount of time would be necessary to successfully complete the project. Letters were sent to 45 operators and a total of 15 operators were interviewed. The low success ratio of farmers interviewed, 33%, was appreciably lower than the MDA's past record of 66% to 75% success ratio. However, despite the low success rate, 30% of all acres in the F-SWA was assessed through FANMAP.

The Minnesota Department of Agriculture used a data gathering tool and analysis system called the Farm Nutrient Management Assessment Program (FANMAP). FANMAP was developed seven years ago to provide an 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 one to two 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 and from the fertilizer tonnage fee account at the MDA.

Nutrient Information of the Selected Farms in the Fairmont Source Water 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 inventoried acres within the Dutch Creek Watershed and portions of the Chain of Lakes Watershed of the F-SWA**. Soil and manure testing results were also collected if available. Nutrient inputs and yields were specific for the 1999 cropping season. Crop types and manure applications (starting in the fall of 1998) were also collected for the 1998 season for purposes of 1999 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 from the fertilizer dealer if the dealer kept the farmer's records.

Farm Size, Crop and Livestock Characteristics of the Selected Farms in Fairmont Source Water Area

Fifteen farmers were interviewed during January and February of 2000. Some of the "farmers" were actually a combination of farmers such as a father and son who farmed together. A total of 6,038 acres of farmland were inventoried in the F-SWA study for the 1999 crop season. Acres were split between two watersheds with 2,402 acres inventoried in the Chain of Lakes watershed and 3,636 acres inventoried in the Dutch Creek Watershed. Farm interviews covered approximately 23% of all agricultural acres in the Chain of Lakes watershed and 36% of all agricultural acres in the Dutch Creek Watershed. The F-SWA cropland was dominated by a corn-soybean rotation. Figure 1 lists each type of crop grown and the corresponding percentage of acres.

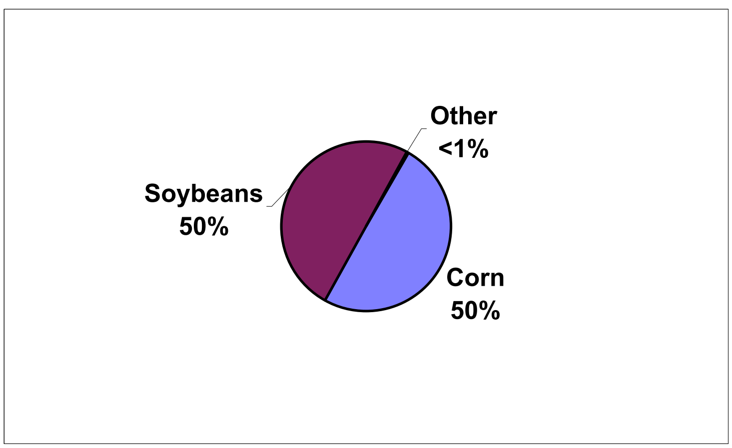
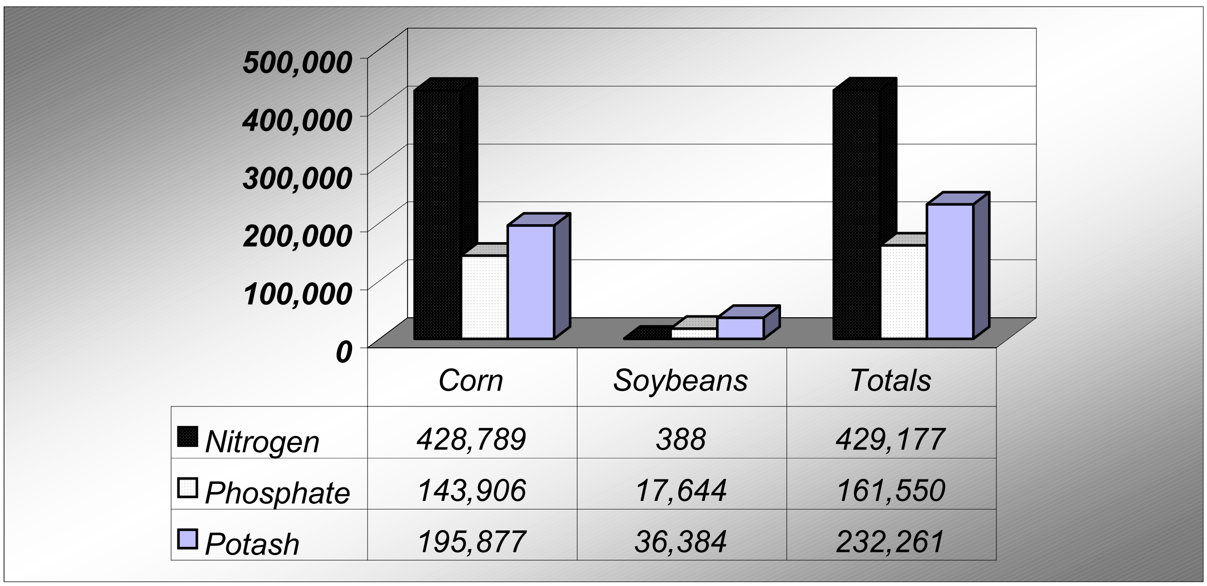


Figure 1. Crop acres inventoried in the F-SWPA. Cropland totaled 6,038 acres with 3,005 acres of corn, 3,016 acres of soybeans, and 17 miscellaneous acres.

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

Commercial Fertilizer Use Characteristics on Selected Farms: Fairmont Source Water Protection Area

Field corn accounted for over 99% of the 429,000 pounds of commercial N fertilizer use (Figure 2). All corn acreage received either commercial N fertilizer or manure. Ninety-eight percent (98%) of all corn fields received commercial N fertilizer. Average fertilizer N rate across all corn acres was 143 lb/A. Total N inputs will be discussed later in the "Nutrient Balances and Economic Considerations" section. Phosphate (P_2O_5) and potash were generally applied the fall or spring prior to planting corn. The general practice is to apply enough P_2O_5 to the corn and have adequate carry-over benefits for the soybean crop. Total P_2O_5 and K inputs will be discussed later in the "Nutrient Balances and Economic Considerations".



	Corn	Soybeans	Totals
Nitrogen	428,789	388	429,177
Phosphate	143,906	17,644	161,550
Potash	195,877	36,384	232,261

Figure 2. Commercial fertilizer use on all inventoried acres.

Best Management Practices (BMP's) for nitrogen use on corn have been developed for south-central Minnesota. Timing of N fertilizer applications on corn is an important consideration on the fine-textured soils in south-central Minnesota[2]. Applications of nitrogen before spring planting are highly recommended in the F-SWA. Fall application in this region is not the recommended practice due to the likelihood of significant N leaching losses. Fifty-two percent of commercial N applied to corn was either preplant or at planting (Figure 3).

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

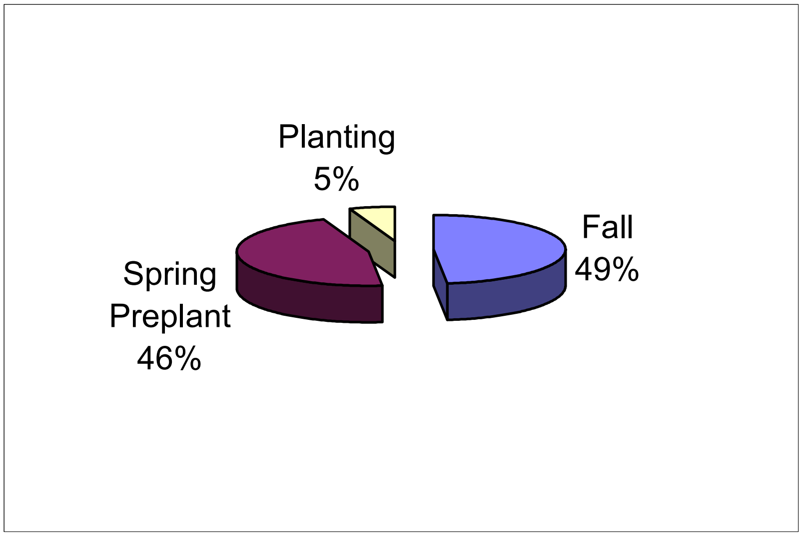


Figure 3 Timing of 1999 N fertilizer applications across all inventoried corn acres.

There were no side-dress applications of N and no nitrification inhibitor was used in any of the commercial N. Liquid N (UAN[3] solutions) supplied 38% of the total amount of commercial N applied to all inventoried corn acres (Figure 4).

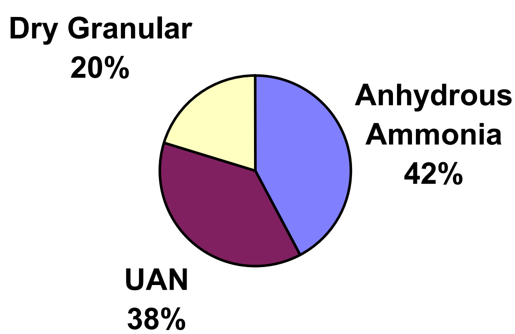
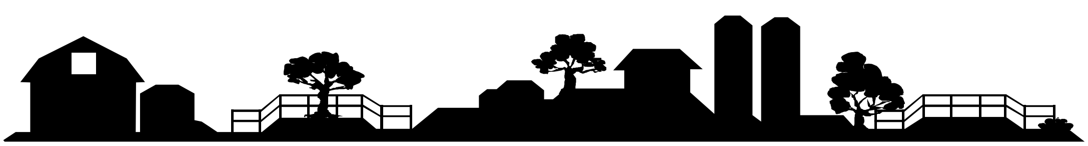


Figure 4. Sources of commercial N used on all inventoried corn acres.



[3] Urea Ammonium Nitrate or commonly referred to as “28%” or “UAN”.

Farmers were generally applying the majority of N as anhydrous ammonia in the fall and as U.A.N solutions in the spring preplant[4] application (Figure 5). For this analysis, "Planting" does include those applications of N applied within two days of planting. Most of the fall-applied and planting dry granulars were DAP[5].

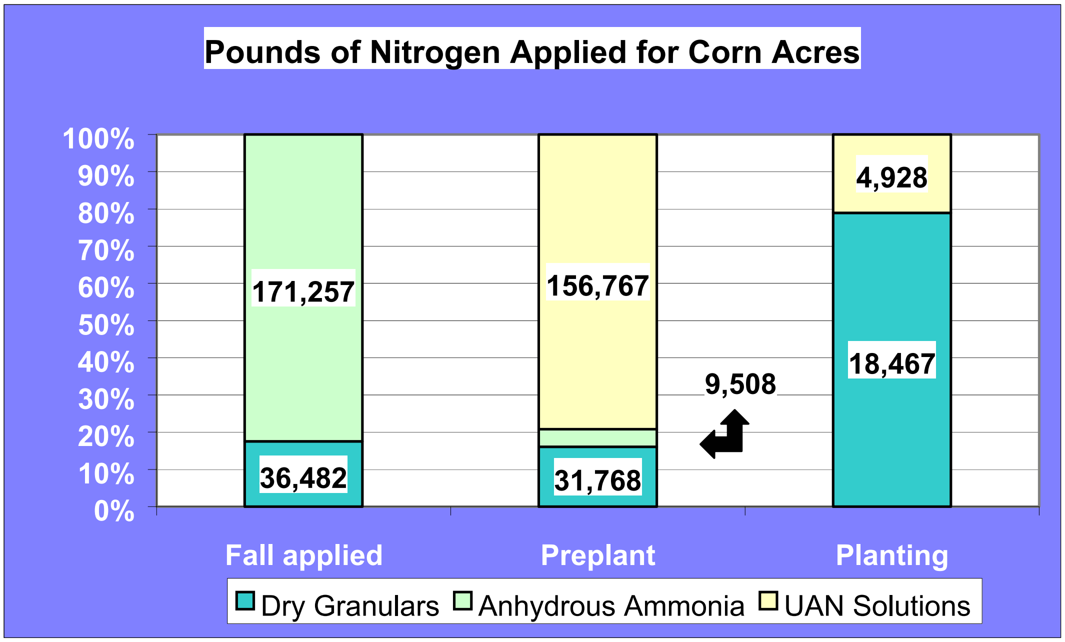


Figure 5. Sources of N dependent on timing.

Livestock and Manure Characteristics of the Selected Farms:

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 1 includes a complete animal inventory, including estimates of N, P_2O_5 and K_2O produced[6] and collected in various types of manure systems for spreading on inventoried acres (manure collected but not spread on acres specified 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 or manure that was spread on land that was not within the F-SWA. Livestock numbers represent the inventory on hand from the fall of 1998 to the summer of 1999. This is the livestock that would contribute manure to the 1999 crops (Six of the fifteen farmers had livestock within the F-SWA). In comparing Martin County livestock inventories to the number of farmers interviewed with livestock, it appears that the hog farms are under-represented in the survey when compared to the livestock inventory from Martin County.

[4] Spring preplant is any application in the spring and prior to two days of planting
[5] Diamonium Phosphate with an analysis of 18-46-0.
[6] Livestock Waste Facilities Handbook, Midwest Plan Services, Iowa State University, Ames, Iowa. 1993.

Manure N produced by livestock in the Fairmont area is the basis for beginning analysis of contributions of N from manure to N available to crops. All manure produced by the livestock inventoried was collected, as there was no pasture or large lots where manure was not collected. Hog manure supplied 65% of the total amount of N produced and collected from all livestock raised on the farm (Figure 6). All hog manure was liquid and all beef manure was solid.

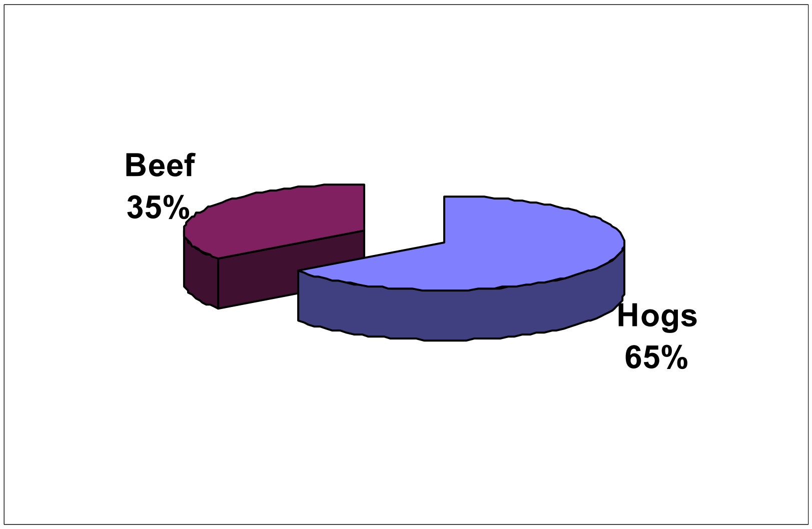


Figure 6. Nitrogen credits from manure for hogs (liquid storage) and beef (solid storage).

Table 1 further details the specific type of livestock and their respective manure nutrient contributions on the inventoried farms. Nutrient losses from collection and storage were estimated from accepted guidelines[7] for each individual storage system. Manure nutrients available are the nutrients collected minus the system storage nutrient losses specific for each type of storage system

Table 1. 1999 livestock numbers, and manure N, P_2O_5 and K_20 produced and available to spread after system losses by livestock types in sample population.

Livestock Type	Livestock Number	Manure Nitrogen Collected	Manure Nitrogen Available	Manure P_2O_5 Collected	Manure P_2O_5 Available	Manure K_2O Collected	Manure K_2O Available
		Pounds		Pounds		Pounds	
Sows or Boars	1,590	43,545	33,965	30,195	30,195	30,195	30,195
Feeder Pigs	29,750	28,560	22,277	17,255	17,255	17,255	17,255
Slaughter Hogs[8]	7,550	66,060	51,527	46,950	46,950	50,629	50,629
Beef Feeders	600	74,400	58,032	54,600	54,600	66,000	66,000
TOTALS	**39,490**	**212,565**	**165,801**	**149,000**	**149,000**	**164,079**	**164,079**

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

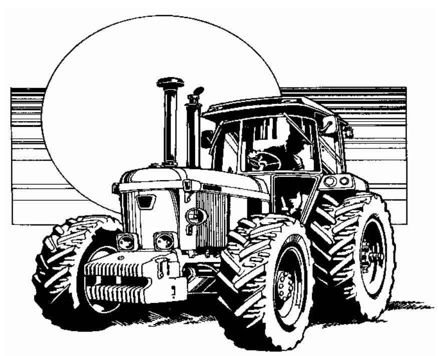
[8] Slaughter Hogs and Feeder Pigs are the number of animals sold/raised per year. All other numbers are average number of animals on hand per year.

Losses as a function of application methods and timing factors were calculated on a field-by-field basis. Amounts of N, P_2O_5, and K_2O available for land application for inventoried cropland are summarized by livestock type in Table 2. A significant percentage, 36% of the N and 43% of the P_2O_5, generated on the farms was land applied outside of the F-SWPA. Some manure that was collected did not go on the acres within the F-SWPA.

Table 2. Contributions of Manure N Available to Spread (After Manure System Losses) by Livestock Type.

System Type	Manure Nitrogen Available to Spread	Manure P_2O_5 Available to Spread	Manure K_2O Available to Spread
	Pounds	**Pounds**	**Pounds**
Solid Beef Manure	58,032	54,600	66,000
Liquid Hog Manure	107,768	94,400	98,079
TOTALS	**165,801**	**149,000**	**164,079**
Exported Manure	-59,814	-63,770	-58,341
Total available to spread on F-SWPA	**105,987**	**85,230**	**105,738**

All cattle manure (solid) was spread without incorporation on the inventoried acres. All hog manure (liquid) was sweep incorporated on the inventoried acres. Figure 7 details the amount of first year available N to the crops within the F-SWPA. Generally, only 25% of the beef manure N applied was first year available to the 1999 crops due to non-incorporation within 4 days and generally 80% of the hog manure N applied was first year available because of sweep injection.



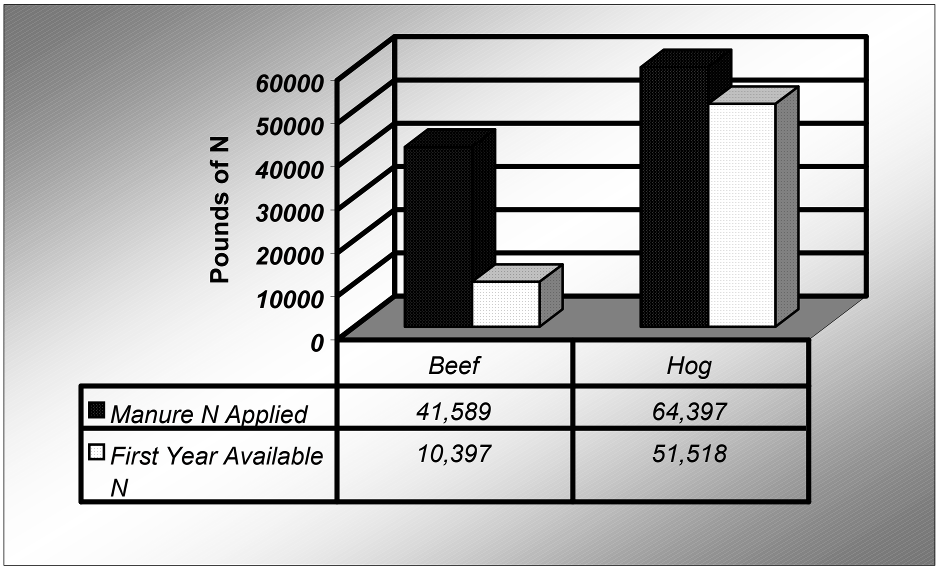


Figure 7. Manure retained for spreading by type of livestock and amount of N available to crop after application losses.

According to UM, eighty percent of the P_2O_5 (54,548 pounds) and potassium (67,673) was first year available to the inventoried crop acres (Figure 8).

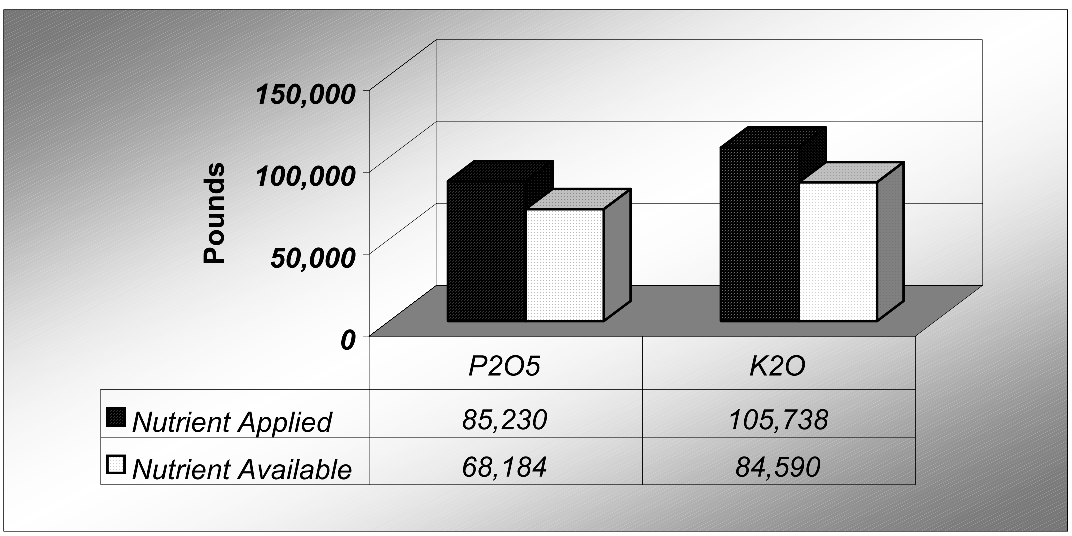


Figure 8. P_2O_5 and K_2O available to inventoried crop acres.

Approximately 76% of the manure was fall-applied (Figure 9).

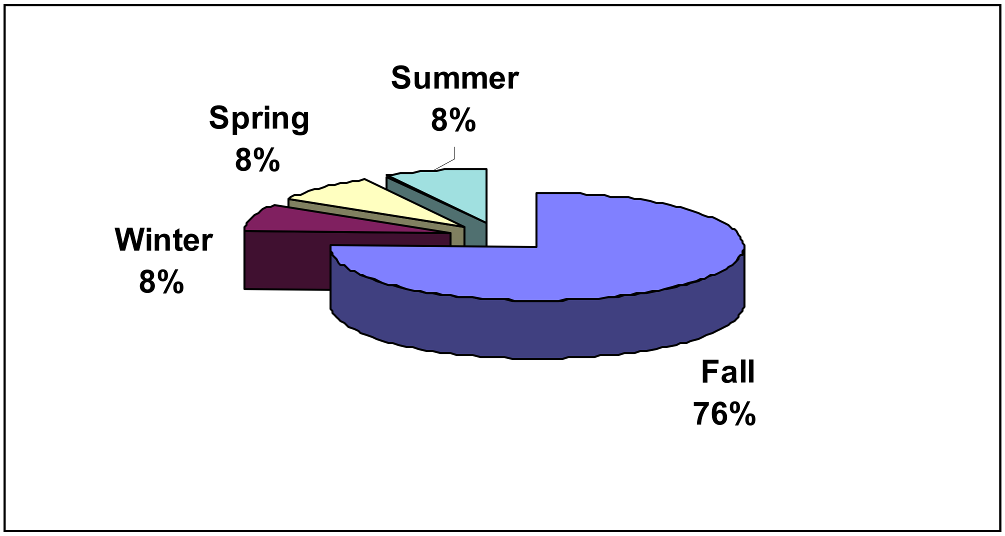


Figure 9. Timing of manure applications on all acres based on manure N availability.

Manure was applied on cropland previous to planting both corn and soybeans (Table 3).

Table 3. Distribution of First Year Available Manure N Across All Crop Acres.

Crop	Acres	Available N
Corn	575	37,015
Soybeans	500	24,900
Totals	1,075	61,915

Relative Importance of Nutrient Sources on the Selected Farms: Fairmont Source Water Area

The University of Minnesota recommends proper crediting of legume crops for their N contributions to subsequent crops. Soybeans should provide a 40 lb N/A credit. Alfalfa credits were available on only 78 acres of corn in the study area and should provide 50 lb N/A for second year alfalfa credits. The general crop rotation for the inventoried farmers was a corn-soybean rotation for the majority of the acres. Soybeans was the most important source of legume N, supplying approximately 95% of all legume N.

Commercial fertilizers (70%), manures (10%), and legumes (20%) contributed a total of 612,000 lb of "first year available N" to all inventoried acres in 1999 (Figure 10).

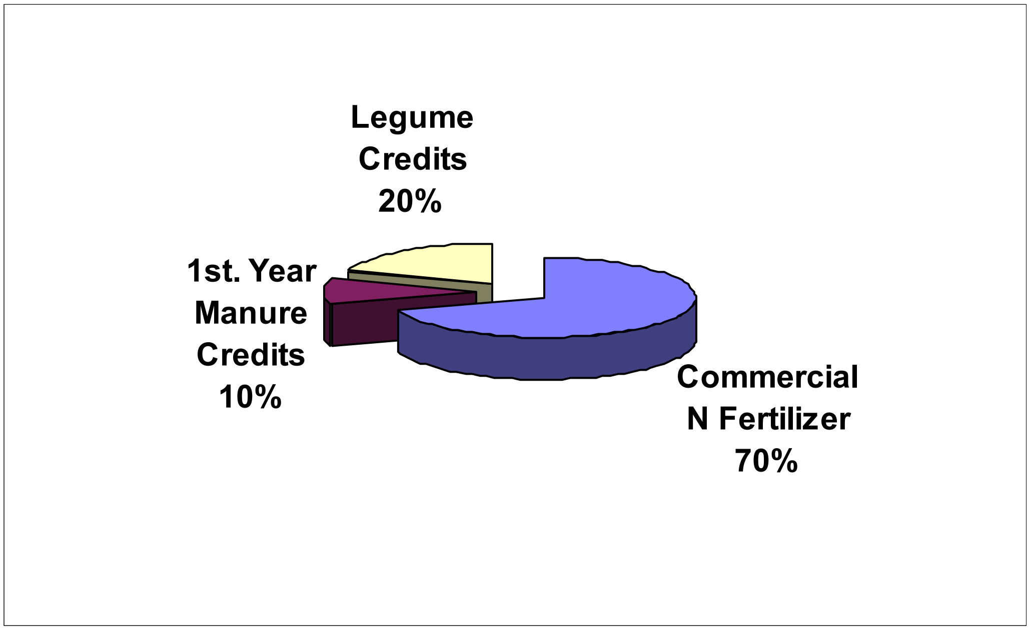


Figure 10. Relative N contributions from fertilizers, manures and legumes across all crop acres inventoried in 1999. Nitrogen inputs totaled 612,000 lb for all sources across the 15 participating farms.

Commercial fertilizers (70%) and manure (30%) contributed a total of 230,000 lb of P_2O_5 to all inventoried acres in 1999 (Figure 11).

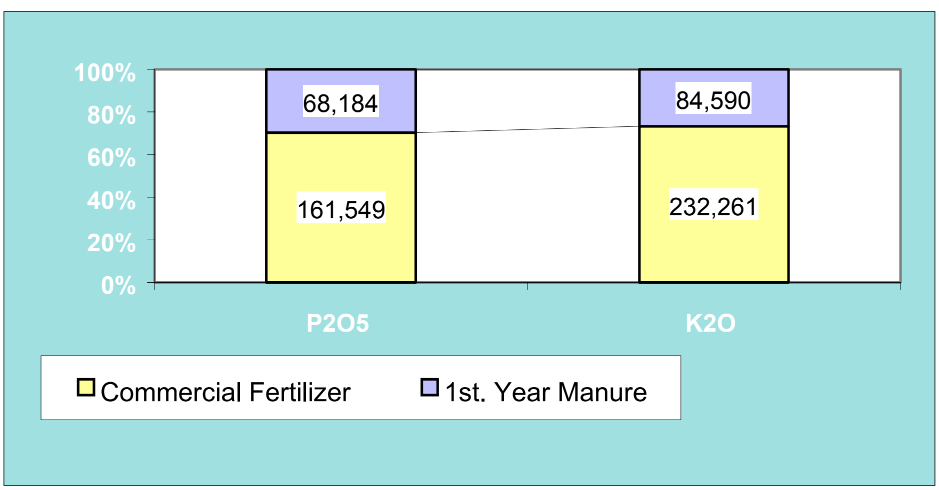


Figure 11. Contributions of P_2O_5 and K_2O from manure and commercial fertilizer sources.

Nutrient Balances and Economic Considerations: Fairmont Source Water Area

Contributions of N from commercial fertilizer and manure to inventoried acres totaled 491,000 lb. Corn received 466,000 lb of N and soybeans received 25,000 lb of N. The corn yield goal across all farms averaged 165 Bu/A while historic yields averaged 151 Bu/A. Yield goals for corn were approximately 14 Bu/A greater, than average yields for the past five years. It appears farmers are over-estimating yields by approximately 10%.

University of Minnesota recommendations are based on economic and environmental factors. Research at both the Southwest Research & Outreach Center (Lamberton) and the Southern Research & Outreach Center (Waseca) has shown that the recommendations are based on sound economic decisions and, in the long term, generally result in the most economic profit. 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. In the fall of 2000, the UM released new fertilizer recommendations for corn. This analysis will compare actual amounts of N to both the old and new UM recommendations. In this survey, all soils in the F-SWA are considered medium to high in organic matter based on soil surveys and actual soil tests.

Previous University of Minnesota N recommendations for corn averaged 109 lb N/A (Figure 12). New University of Minnesota N recommendations for corn averaged 124 lb N/A. Actual amounts of N applied from fertilizer and manure averaged 155 lb A across all corn acres. Factoring in all appropriate credits from fertilizer, legumes and manures, there was an over-application rate of 46 lb/N/A according to the old UM recommendations and an over-application rate of 31 lb/N/A according to the new UM recommendations.

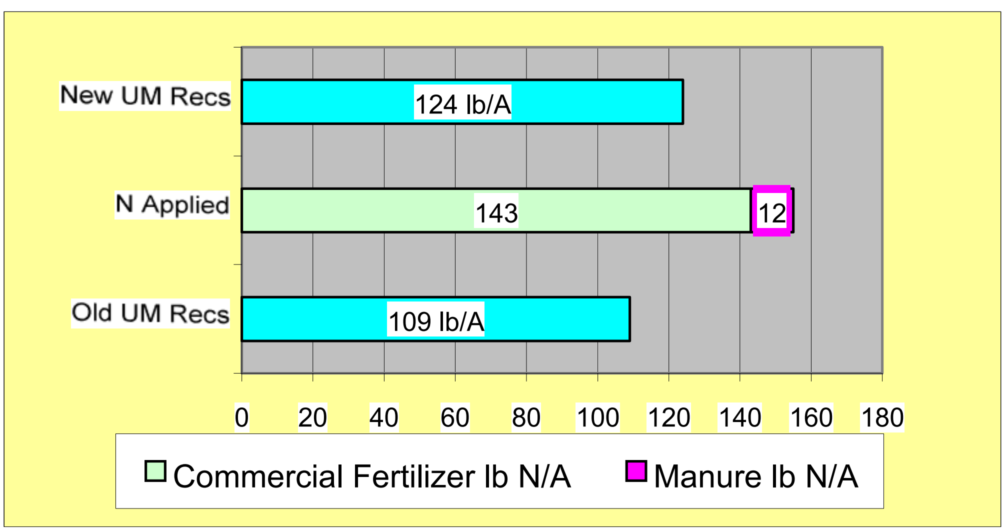


Figure 12. 2000 crop N requirements based on University of Minnesota N recommendations in comparison to actual N inputs (fertilizer and manure) for **corn acres** in the inventoried area. Average N application was 155 lb N/A.

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. Factoring in legume N credits and manure N credits into the process on a field-by-field basis, the amounts in excess of 1999 UM recommendations are illustrated in Figure 13. The 1999 UM recommendations were used because that was the information that was available to the farmers for the crop year of 1999.

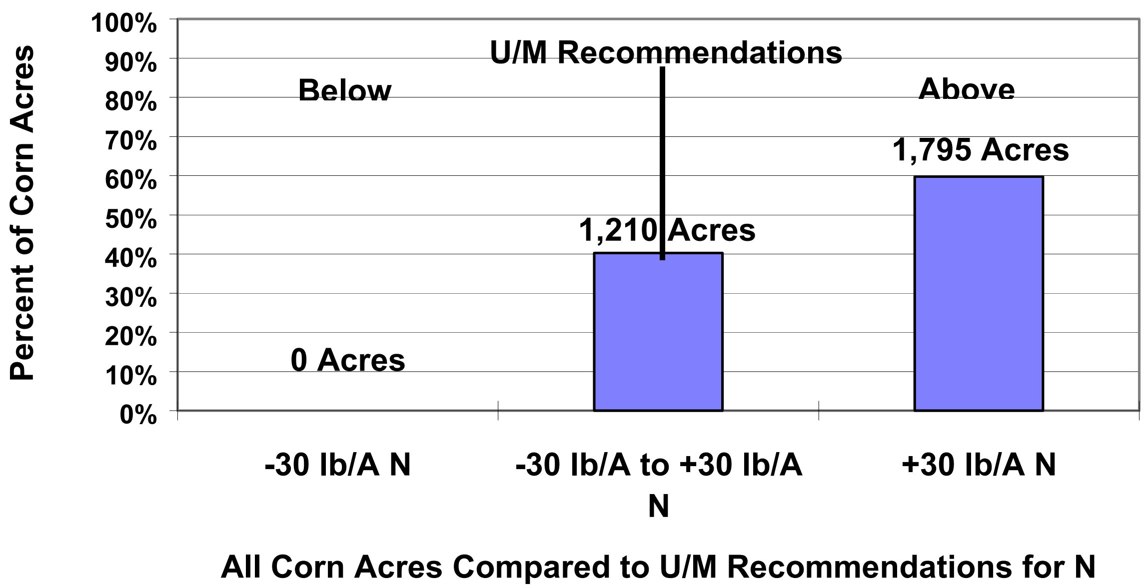
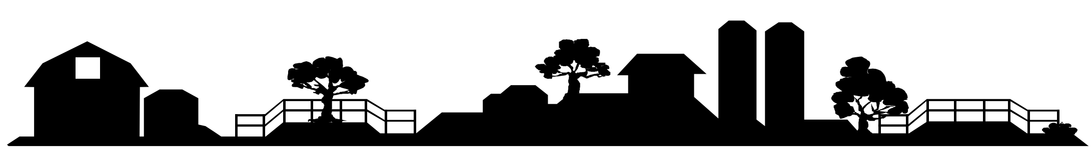


Figure 13. Corn acres that fall within plus and minus 30 pounds of the 1999 UM recommendations for N.

Sixty percent (60%) of the corn acres were classified in the excess UM category according to the previous (1999) recommendations. By reducing the N applied on fields in the excess category to within 30 lbs of the UM recommendations, N applied to corn acres would actually decrease by 75,000 lbs.

New UM recommendations (2000) have slight increases in the amount of N required for corn. When comparing what the farmers are currently applying for N to the new recommendations, there is less over-application (Figure 14).



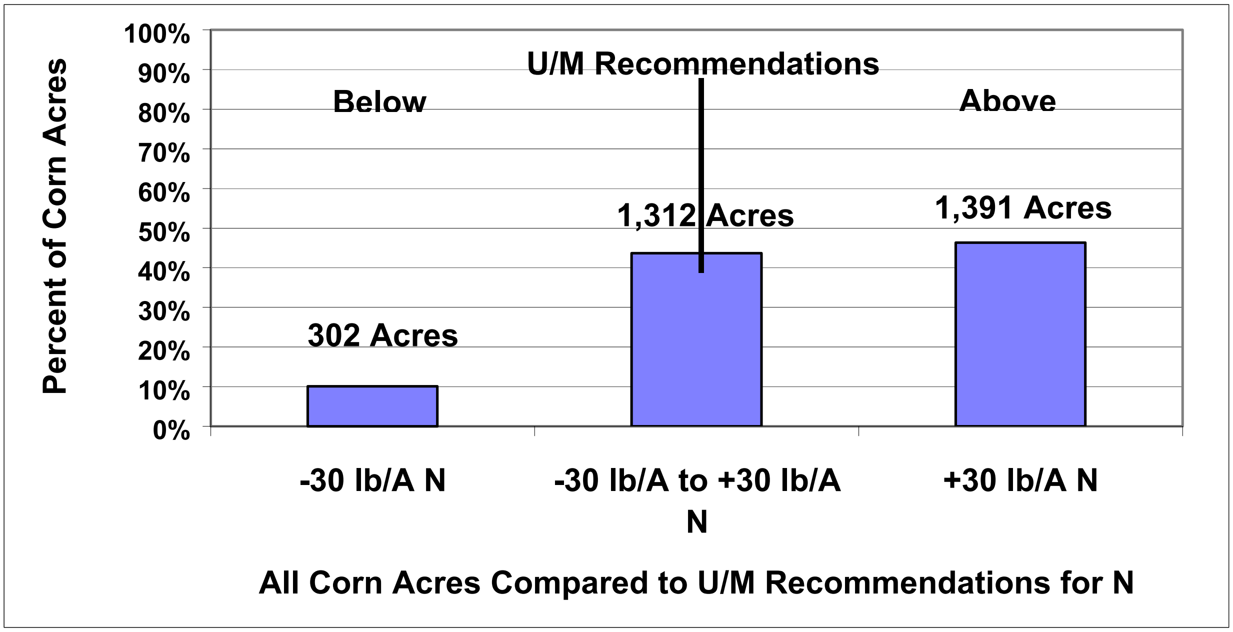


Figure 14. Corn acres that fall within plus and minus 30 pounds of the new (2000) UM recommendations for N.

Corn acres receiving N credits from manure accounted for 575 corn acres. When looking specifically at those corn fields applied with manure a total of 123 acres (21%) of were over-applied with N in excess of 30 lbs/A. Overall 60% of the fields were over-applied with N. It appears that there was less over-application of N on those fields with manure compared to those fields without manure.

Phosphorus is a major concern in the F-SWA. Phosphorus is the primary nutrient that leads to the eutrophication of lakes. Eutrophication, a slow aging process of surface water bodies, leads to increased organic material in the water, i.e., algae. Phosphorus is usually associated with sediment carried by surface water runoff. The City of Fairmont uses chlorine to disinfect source water prior to distribution. When chlorine is added to the water with organic material, compounds called trihalomethanes (THMs) develop as a treatment byproduct. New rules by the EPA will reduce maximum contaminant level (MCL) of THM by one half in 2002. With these new rules, Fairmont's drinking water will be very close to being above this new standard. Therefore, the city of Fairmont will be looking at many possibilities to reduce phosphorus loading into the Chain of Lakes.

There was a total of 216,000 pounds of phosphorus applied on inventoried acres in the F-SWA. Ninety percent (90%) of the commercial phosphorus and 72% of the manure phosphorus was applied either in the fall or spring prior to planting the corn crop. Farmers generally applied commercial phosphorus every other year on the corn acres.

The University of Minnesota recommendations for P_2O_5 applications on corn are based on the soil tests for phosphorus. In the F-SWA, farmers used both the Olsen and the Bray soil P tests. Generally, the Olsen test should be used on soils with a pH of 7.4 or higher and the Bray test should be used for a pH of 7.3 or lower. Farmers were generally following this practice in the F-SWA. There were 325 acres with a Bray soil test and 1,945 acres with an Olsen soil test. Figure 15 details the distribution of all soil P tests across inventoried acres. Most farmers did have recent soil tests, however the results were not available at the time of the interviews. These soil tests were generated for the soils in the last five years.

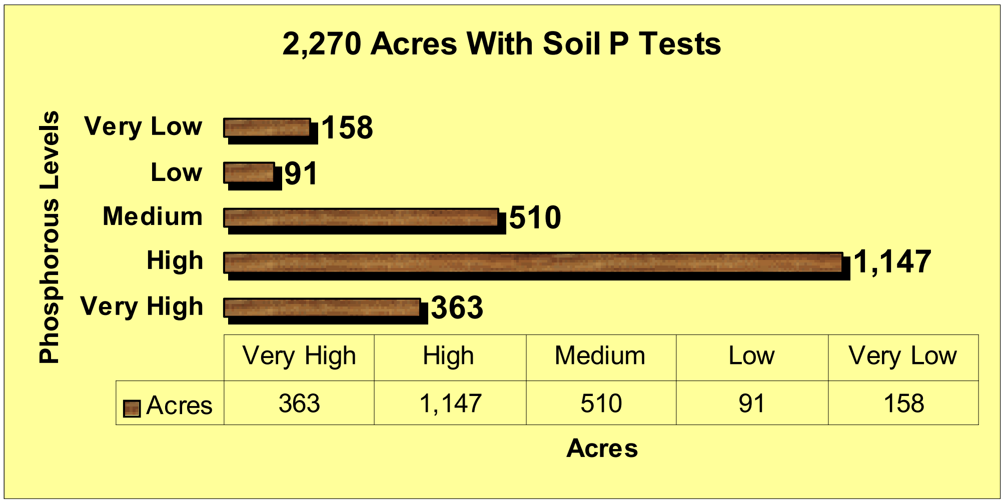


Figure 15. Soil P test results across all inventoried acres with soil tests. Soil test ranged from 3 ppm Olsen to 39 ppm Olsen, which was the phosphorus test used on the majority of the inventoried acres.

Recommendations for phosphorus applications in this analysis are based on research by Gyles Randall, UM Soil Scientist and co-author of the UM publication Fertilizing Corn in Minnesota. Twenty years of study at both the Southern (Waseca) and the West Central (Morris) Research & Outreach Centers suggest that soil P tests will remain relatively stable with annual applications of 50 lb P_2O_5 /A. However, economic returns increased with every-other-year applications of 100 lb P_2O_5/A. According to the study, soil test values can be maintained at 20 ppm Bray or 16 ppm Olsen with yearly applications of 40 to 50 lb/ P_2O_5/A. Soil test phosphorus will decline by 1-2 ppm P/year with no applications to a corn soybean rotation.

Average P_2O_5 yearly applications from all sources on the inventoried acres in the F-SWA averaged 38 lb P_2O_5/A. Average P_2O_5 yearly applications from all sources on manured acres averaged 66 lb P_2O_5 /A. Additional P_2O_5 analysis was not possible due to the limited soil test information in this study area.

Conclusions and Summary of the Current Nutrient Management Practices for the Fairmont Source Water Area.

The Fairmont Source Water Area consists of medium to heavy soils in south-central MN. Fifteen farms, covering 6,000 acres, participated in the FArm Nutrient Management Assessment Program (FANMAP) with staff from the Minnesota Department of Agriculture. Producers volunteered one to two 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 utilizes this knowledge for future water quality educational programs.

Fifty percent (50%) of the crop acres were planted with soybeans and 50% with corn. Over 429,000 lb of commercial N was applied to crops for the 1999 growing year. Over 99% of the commercial N was applied for corn in 1999. Anhydrous ammonia, U.A.N. solutions and dry granulars accounted for 42%, 38% and 20% of the N respectively. Timing of N applications occurred in fall (49%) and spring (51%) with no sidedress applications. Nitrogen inhibitors were not used on the inventoried acres.

Manure (first year available) from beef cows accounted for 17% of manure N with hog manure accounting for the balance. Hog manure was collected as a liquid while beef manure was collected as a solid. Manure accounted for 10% of the N while legumes and commercial N accounted for 20% and 70%, respectively. Soybeans were the dominant source of legume N credits.

Farmers, on average were over-applying N by 46 lb N/A according to the previous (1999) UM recommendations and 31 lb N/A according the current (2000) UM recommendations. Sixty percent (60%) of the farmers were over-applying N by more than 30 lb N/A according to the previous (1999) UM recommendations, and 46% of the farmers were over-applying N by more than 30 lb N/A according to the current (2000) UM recommendations. On manure acres only, 21% of the farmers were over-applying N by more than 30 lb/N/A.

Phosphorus is a major concern in the F-SWA because of algae growth in the Fairmont chain of lakes. There was a total of 216,000 lbs of P applied on inventoried acres with farmers generally applying P after the soybean crop and before the corn crop. Sixty-seven percent (67%) of the soil tests were in the high to very high level for P. Without better representation of the farmers in the F-SWA and additional information from them, phosphorus management could not be assessed in regard to BMP's.

There were some very positive findings from this study. There is strong evidence that corn and soybean producers are voluntarily adopting the educational materials and recommended N management strategies developed by the University of Minnesota. It appears overall rates of N could be reduced, and, if soil P test levels are representative, some P_2O_5 applications could also be reduced or eliminated. It is also evident that promotional activities need to continue and be specifically targeted to deliver the most recent advances in technology and revised N management and new UM recommendations.