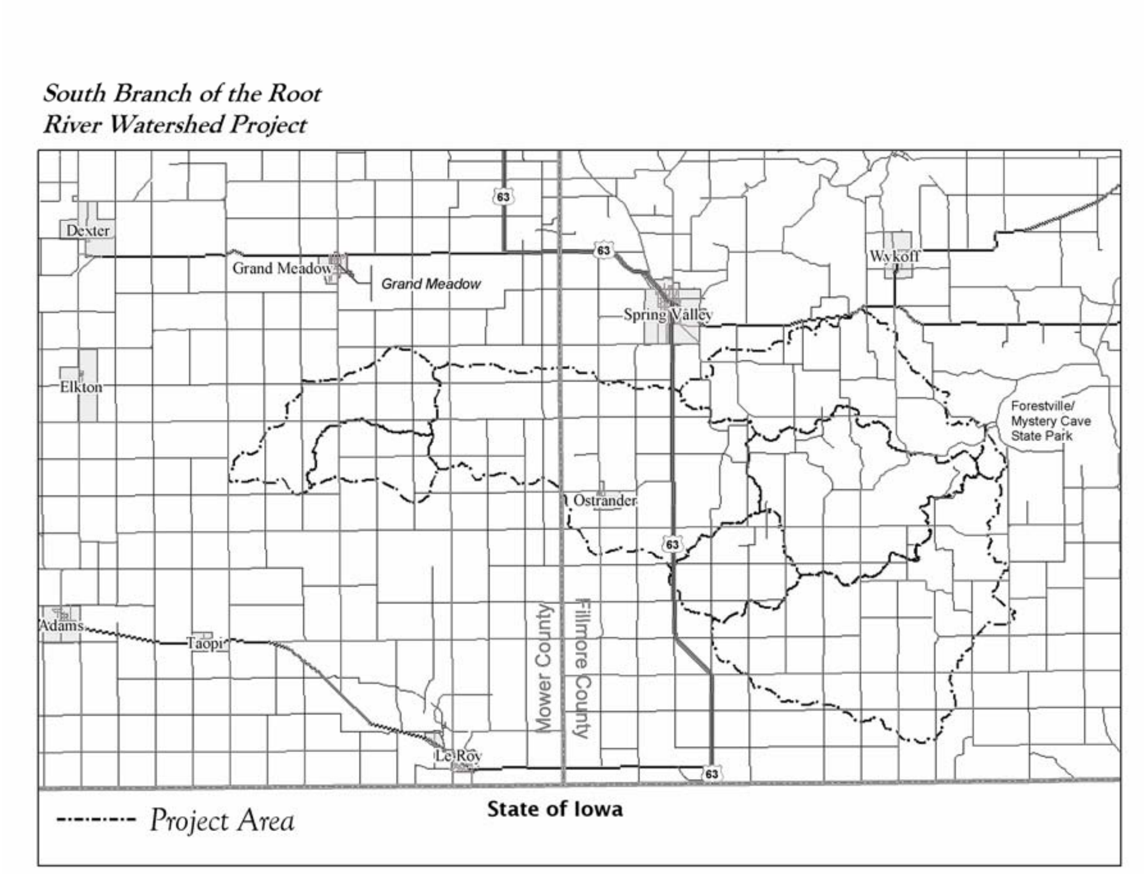
2003 Nutrient Management Assessment of Producers South Branch of the Root River



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General information:
The South Branch Root River (SBRR)
(Information Provided by South Branch Root River Watershed)

The South Branch Root River (SBRR) Watershed Project is a collaborative effort to help protect and enhance the water quality of the South Branch of the Root River. The project area begins in the headwaters of the South Branch of the Root River west of Forestville/Mystery Cave State Park in southeastern Minnesota. The 74,330-acre project area lies in western Fillmore County and eastern Mower County. The Mower County portion comprises about 15,700 acres (21%) of the project area.

Forestville/Mystery Cave State Park marks the downstream extent of the project area. The main park lies at the confluence of the three major drainages of the Upper South Branch Root River Watershed. These drainages are highly complex due to the karst (dissolved limestone) characteristics of the area. Surface waters beginning in the flat, glaciated soils of eastern Mower County flow generally easterly until encountering crevices and cave systems, at which point some or all of the flow moves into the subsurface, depending on flow conditions. These streams reemerge as springs in or near the park producing three of Minnesota's best trout streams: Canfield Creek, Forestville Creek, and the South Branch Root River. The park has evolved into one of Minnesota's most popular state parks with about 140,000 visitors each year. The park offers a tremendous variety of resources and recreation. Many of the park's favorite resources and activities relate to the streams, which makes the park particularly vulnerable to effects of the watershed. The park's popularity and its significant natural and cultural resources were factors in designating the project area.

Historic towns dot the landscape as the South Branch winds its way past the beautiful karst topography. Almost the entire SBRR project area is rural, and agriculture is the major land use. Over 80 percent of the land in the project area is cultivated with the primary crops being corn and soybeans. The remaining 20 percent is almost evenly divided between woodlands or grasslands. Logging is common in the lower watershed. The city of Ostrander (population 212) is the only incorporated city in the project area.

In 1998, the MN Pollution Control Agency (MPCA) awarded the project a Clean Water Partnership Phase I grant to complete a diagnostic study of the project area, which included water quality monitoring and assessments for the subwatersheds. Among the findings, based on water quality monitoring from 1998 to 2002, the geometric mean for fecal coliform bacteria levels at the monitoring station at Historic Forestville were over twice the surface water quality standard of 200 organisms/100 milliliters (mL) of water. Geometric means in the other subwatersheds varied from 145 org/100 mL to 2346 org/100 mL. The geometric means for turbidity was about 85 NTUs (nephelometric turbidity units), which is over 8 times the water quality standard for trout streams, and over 3 times the standard for warm water streams. The highest concentrations of both pollutants were associated with runoff events, some of which were some of the worst flooding seen in over 50 years in the region. These findings led to this segment of the

South Branch of the Root River to be included on the 2004 303(d) Impaired Waters Listing submitted by MPCA to the U.S. Environmental Protection Agency.

In 2003, Governor Tim Pawlenty announced the 10-year Clean Water Initiative, which focused efforts in southeastern Minnesota to reduce fecal coliform bacteria in streams by 65% and turbidity by 30%. The Root River was chosen as the pilot watershed for the Initiative with the SBRR project area designated as a special focus area for the first three years.

In 2004, the project was awarded $299,420 for a 319 Implementation Project plus $300,000 in Clean Water Partnership Loan funds. The implementation strategies are aimed at reducing fecal coliform bacteria levels by 20% and turbidity levels by 10% over three years. Major components include upgrading 40-50 malfunctioning septic systems and installing 10-20 milkhouse waste systems utilizing the low-interest loan funds. The 319 grant funds will be used for cost-sharing low-cost feedlot fixes and for incentive payments for planting buffers to hay or grass which can be harvested and buffer bonus payments for conservation tillage, cover crops and nutrient management on acres adjacent to conservation buffers. Other incentives will be offered for developing forest stewardship plans and voluntary conservation easements. Monitoring and evaluation will continue over the three-year project. FANMAP interviews are among the evaluation tools comparing the results from this round of interviews about tillage and nutrient and pest management practices with a second round to be conducted towards the end of the grant period.

South Branch Root River Watershed
Summary of Stream Monitoring Activities for 1998 to 2002
(Background Information Provided by South Branch Root River Watershed)

Stream monitoring was conducted in the South Branch Root River watershed at three primary sites along the main stem of the river and at five secondary sites on the major tributaries from 1998 to 2002 as part of a Phase I Clean Water Partnership Diagnostic Study. The data helped establish a baseline for water quality conditions in the watershed, which were scarce to nonexistent in the past. However, 1999 and 2000 saw some of the worst flooding in the area in 50 years, so the data is more of a representation of “worst case scenario” conditions than baseline. Even so, the results of the monitoring still helped identify the land use changes needed to remediate water quality impairments that were documented. As a result of the documented exceedances of some water quality standards in the streams in the watershed, this segment of the Root River was added to the 2004 Section 303(d) Impaired Waters List for the state of Minnesota.

Among the chemical parameters analyzed during the 1998-2002 time period were ammonia nitrogen, total nitrogen, chloride, and total phosphorus, as well as total suspended solids, turbidity, and fecal coliform bacteria. On-site measurements of temperature, dissolved oxygen, specific conductivity, and transparency were taken with portable handheld instruments. Stream stage measurements were recorded at the three primary sites using automated instrumentation which recorded stage and precipitation every 15 minutes. Flow and discharge measurements were done at each of the primary sites to establish flow rating curves so that flow could be predicted from the computerized stage record.

Citizen Stream Monitoring Program (CSMP) volunteers also collected transparency and precipitation data for as many as 13 sites throughout the watershed during the 1998-2002 timeframe. Many of these volunteers continue their monitoring at this time. One permanent monitoring station remains in place at the downstream extent of the project area at the Historic Forestville bridge in the state park. It records turbidity, pH, temperature, and conductivity using automated instrumentation from April to November. Grab samples are collected at least twice a month to measure bacteria and nutrient levels.

In cooperation with the MN Department of Agriculture, pesticide monitoring began at the Forestville site in 2002. Winter base flow samples and spring post-planting samples are collected during each growing year. Samples are analyzed for 20 base neutral pesticides.

Transparency
All sites exhibited transparencies greater than 60cm over much of the monitoring period (although this is not true of one site monitored by a citizen). During periods of runoff, transparency dropped as low as 1cm on Forestville Creek. This measurement was associated with an extremely high total suspended solids concentration (2900 mg/l). Canfield Creek and Judicial Ditch 1 had the highest average transparency. At the Upper South Branch site, several transparency readings were in the 40-60 cm range even during low flow conditions. This may have been the result of algae growth in the slow moving water of the upper site “clouding up” the water a bit.

Total Suspended Solids
Total suspended solids (TSS) include sediment, algae, and other organic matter. More than any other chemical parameter, TSS varies with flow. Under high flow conditions, concentrations in the watershed increased by factors of up to 2000. Of the three primary monitoring sites, the upper site had an average concentration of about ½ that of the middle and lower sites. The highest TSS concentration was observed on Forestville Creek on May 18, 2000. Based on hydrologic data from the primary sites, this was perhaps the third highest flow that occurred in the year 2000. This suggests that lack of crop cover may be an important factor along with flow.

Turbidity
Turbidity is a measure of how well light can be transmitted through water. There is a state water quality standard for turbidity based on the protection of aquatic life. High turbidity may directly impact the health of aquatic life or their ability to function properly (e.g. difficult for sight feeding fish to locate prey). In addition, there may be indirect impacts from the material that causes high turbidity (e.g. siltation of habitat). State of Minnesota water quality rules include a turbidity standard of 25 NTUs for warm-water streams and 10 NTUs for trout streams. The mean turbidity of 80 water samples collected under a variety of flow conditions between 1999 and 2002 was about 85 NTUs (nephelometric turbidity units). This is over 8 times the water quality standard for

coldwater trout streams (10 NTUs) and over 3 times the warm water standard (25 NTUs). Turbidities over 1000 NTUs were observed during several runoff events.

Total Phosphorus
The U.S. Environmental Protection Agency has suggested a goal of 0.1 mg/l total phosphorus (TP) to prevent eutrophication impacts. In streams, these impacts may include excessive algae growth on rocks and other river substrate, as well as unstable dissolved oxygen concentrations. This goal was only exceeded on a few dates during high flows. Since sustained high phosphorus levels are probably necessary to cause eutrophication, phosphorus may not be a serious problem in the watershed itself. The thousands of pounds of phosphorus exported from the watershed each year may, however, have significant implications for water quality downstream.

Total Ammonia Nitrogen
Ammonia is produced during the decomposition of nitrogen-containing organic matter. It can be toxic to aquatic animals and his been implicated in fish kills in southeastern Minnesota. In water, ammonia exists in un-ionized and ionized forms. The un-ionized form is toxic to aquatic animals. The relative abundance of the two forms in controlled by pH and temperature. While total ammonia concentrations increased somewhat when runoff carried organic matter into the streams of the watershed, they did not approach levels where toxicity would have been a problem (assuming typical pH levels, which were not monitored).

Nitrite + Nitrate Nitrogen
There is no surface water quality standard for nitrate nitrogen. However, given the interconnected nature of surface water and ground water in southeastern Minnesota, the drinking water standard of 10mg/l is sometimes held out as a goal for surface waters. While the South Branch of the Root River is not used as a drinking water source, the high concentrations should be a cause for concern as the water in the river reflects water that eventually recharges drinking water aquifers.
This standard was exceeded at least once at all sites within the watershed. In terms of average concentrations, only the upper site and its two tributaries exceeded 10mg/l. The two tributary sites also had the highest concentrations observed during the project of 21mg/l. The lower site and its three cold water tributaries had maximum concentrations of 12 and 13 mg/l. Unlike many other water quality indicators, nitrate was not strongly correlated to flow. A nitrate dilution effect has been reported under conditions of high runoff and flow. Water that has little contact time with soils may not have the opportunity to pick up a great deal of nitrate.

Fecal Coliform Bacteria
Over the two years of monitoring, the water quality standard for fecal coliform bacteria was violated frequently throughout the watershed. Violations include individual observations with a result greater than 2000 organisms/100mL, or a monthly average greater than 200orgs/100mL. Average concentrations were similar for the three primary sites. Of 83 grab samples collected between 1999 and 2002, 24 exceeded 2000 org/100

mL. The overall geometric mean at Forestville was 553 orgs/100 mL, which is greater than 2 times the monthly average water quality standard of 200 orgs/100mL.

While it is difficult to assess the actual threat to human health when the fecal coliform water quality standard is violated, concern is warranted. Unlike many other streams and river is southern Minnesota, there is significant “body contact” recreation in the South Branch of the Root River, particularly the lower portion. While there is no designated swimming beach in Forestville State Park, a significant amount of wading, swimming and tubing occurs. State Park staff indicated that this was particularly true in the hot summer of 2001. Anglers also have a good deal of direct body contact with the water.

Total Chloride

Chloride is a stable, common ionic form of chlorine found in water. It is inert and behaves conservatively in water, meaning it does not react with other substances and does not readily attach to soil particles. The greatest observed total chloride concentration (22mg/l in the upper watershed) is significantly less than the state water quality chronic standard for the protection of aquatic life of 230 mg/l. Chloride concentrations are generally greatest in urban streams, reflecting one of the major sources of chloride: road salt. Domestic wastewater and KCL fertilizer are other human sources of chloride.

Pesticides

Atrazine was detected in all samples collected in the South Branch Root River at Forestville from 2002 to 2004. Atrazine results from discrete samples exceeded the human health based water quality standard of 3.4 ug/L in late spring. However, since the standard is based on a mean concentration of 3.4 ug/L over a 30-day exposure period for human health impacts, a direct comparison of discrete sample concentrations to the standard is not necessarily indicative of water body impairment, but may signal a need for additional monitoring. For comparison, the atrazine standard for toxicity to aquatic organisms is based on a mean concentration of 10 ug/L over a 4-day exposure period. Atrazine concentrations ranged from 0.06 ug/L to 6.8 ug/L in the South Branch of the Root River over this period.

Acetochlor was detected in 7 of the 10 discrete samples collected from 2002 to 2004, twice meeting or exceeding the current aquatic life advisory value of 1.4 ug/L. The Acetochlor reference value is based on a mean concentration of 1.4 ug/L over a 4-day exposure period for aquatic organisms; exceedances of the standard by discrete sample concentrations is not necessarily indicative of water body impairment. Acetochlor was not detected in either of the winter base flow samples in 2003 or 2004. Concentrations of Acetochlor ranged from non-detect to 2.84 ug/L. Metolachlor was also detected in all of the samples collected. None of the samples exceeded the stream aquatic life adivory value of 10 ug/L. Other compounds detected at Forestville included two breakdown products of Atrazine, Dimethenamid, and Metribuzin.

Flow-Weighted Concentrations and Pollutant Loading

Precipitation and runoff were well above normal in southeastern Minnesota and the South Branch Root River watershed for both 1999 and 2000. This was clearly an important factor influencing the amount of three key water pollutants (suspended solids, phosphorus, and nitrate nitrogen) carried in the river.

Flow-weighted mean concentrations, loads, yields, and normalized yields are different, but closely related, expressions of stream water chemistry. It is important to understand what these expressions mean. If one were able to collect all the water that ran past a particular monitoring site for a particular period, mix it all together in a huge container, and analyze a sample; the result would be the flow-weighted mean concentration for that time period. The load would simply be the total amount of any particular chemical, pollutant, or substance in the container. The yield is the load divided by the size of the drainage area. This allows comparison among watersheds of different sizes. Finally, the normalized yield is the yield divided by the amount of runoff. To some degree, comparing normalized yields helps separate the conditions that people have less control over (precipitation, runoff), from those that watershed residents may have more control over (e.g. soil erosion, loss of nutrients).

Total suspended solids includes sediment, algae, and other organic matter. In a relatively small river such as the South Branch of the Root, the majority of the annual total suspended solids load is sediment derived from soil erosion in upland areas, as well as stream bank and bed erosion.

Total suspended solids flow-weighted mean concentrations ranged from 20.1 mg/l at the upper site in 1999, to 131 mg/l at the middle site in 2000. The average concentration for the Root River near its mouth for the decade of the 90's was 99.1 mg/l (MPCA, 1999). The average annual concentration for reference streams in the Western Corn Belt Plains Ecoregion for the years 1970-1992 was 45.3 mg/l (MPCA, 1993). Monitoring of streams in the Upper Mississippi River system from 1993 to 1996 showed average suspended solids concentrations of 40 mg/l for the Cannon River in Minnesota, and 200 mg/l for the Wapsipinicon and Maquoketa rivers in Iowa (U.S. Geological Survey, 1999).

Summing up the subwatershed loads, the South Branch of the Root River transported 18.4 and 33.3 million pounds (9,200 and 16,650 tons) of suspended solids in 1999 and 2000, respectively. On a "per acre" basis, the middle subwatershed yielded more suspended solids than the upper or lower subwatersheds (Figure 3). Over the 2000 monitoring period, this amounted to over 600 lbs./acre, which represents a significant amount of sediment moving off the landscape. The U.S. Geological Survey (1986) reported average annual suspended sediment yields of 173 tons/sq. mile for the South Fork of the Root River near Houston, MN; 249 tons/sq. mile for the Root River near Lanesboro; and 221 tons/sq. mile for the Root River near Houston. The values for the South Branch of the Root River translated into tons/sq. mile are 80 and 144, respectively for 1999 and 2000. When normalized for runoff, the difference between the upper site and lower two sites becomes more pronounced.

Steep topography, and land use practices which expose soil to erosion, are major factors influencing the amount of sediment reaching streams. The middle subwatershed has both conditions. The upper subwatershed exhibits relatively flat topography. The lower subwatershed, while having much topographic relief, also has a higher percentage of land in forest, grassland, and pasture cover. Furthermore, it is likely that a higher percentage of the water in the lower portion of the river comes from the groundwater-fed tributaries of Etna, Canfield, and Forestville Creek. Most of the time these streams have relatively low concentrations of suspended solids.

Total phosphorus flow-weighted mean concentrations ranged from 0.108 mg/l at the upper site in 2000, to 0.394 mg/l at the middle site in 2000. The average concentration for the Root River near its mouth for the decade of the 90's was 0.17 mg/l (MPCA, 1999). The average annual concentration for reference streams in the Western Corn Belt Plains Ecoregion for the years 1970-1992 was 0.28 mg/l (MPCA, 1993). Monitoring of streams in the Upper Mississippi River system from 1993 to 1996 showed average total phosphorus concentrations of 0.2 mg/l for the Cannon River in Minnesota, 0.3 mg/l for the Wapsipinicon River in Iowa, and 0.4 mg/l for the Maquoketa River in Iowa (U.S. Geological Survey, 1999).

Summing up the subwatershed loads, the river transported 57,000 and 100,000 pounds of total phosphorus in 1999 and 2000, respectively. Phosphorus is often attached to sediment, so it is not surprising that the middle subwatershed has the highest phosphorus yield. The differences are not as pronounced as for suspended solids, however, indicating that soil erosion is not the only source of phosphorus. Fertilizer and livestock manure, as well as inadequately treated sewage, are all sources of phosphorus. Yields ranged from 0.4 to 1.7 lbs./acre. These yields are quite high compared to those for 10 Minnesota River Basin streams monitored in 2000; nine of the ten streams had yields less than 0.4 lbs./acre (MPCA, 2001). Normalized yields were more comparable; there was much higher precipitation in southeastern Minnesota than in the Minnesota River Basin in 2000.

Nitrate flow-weighted mean concentrations ranged from 7.5 mg/l at the lower site in 2000, to 13.7 mg/l at the upper site in 1999. The average concentration for the Root River near its mouth for the decade of the 90's was 3.9 mg/l (MPCA, 1999). The average annual concentration for reference streams in the Western Corn Belt Plains Ecoregion for the years 1970-1992 was 4.8 mg/l (MPCA, 1993). Monitoring of streams in the Upper Mississippi River system from 1993 to 1996 showed average nitrate+nitrite concentrations of 4.0 mg/l for the Cannon River in Minnesota, 4.0 mg/l for the Wapsipinicon River in Iowa, and 6.0 mg/l for the Maquoketa River in Iowa (U.S. Geological Survey, 1999).

Summing up the subwatershed loads, the river transported 1.6 and 1.9 million pounds of nitrate in 1999 and 2000, respectively. The upper subwatershed yields 2-3 times the nitrate as the middle or lower subwatersheds. The yields from this subwatershed of 50 lbs./acre in 1999 and 67 lbs./acre in 2000 represent a significant economic loss as well as a threat to water quality. This yield is nearly 4 times that of the highest of the Minnesota River Basin streams monitored in 2000. The normalized yield was greater than nine of the ten Minnesota River Basin streams.

Explanations for the very high nitrate yield from the upper subwatershed include excessive fertilizer and manure applications, untreated wastewater, and the extensive subsurface drainage in the upper part of the watershed. Unlike sediment and phosphorus, nitrate moves very efficiently through the soil profile and tile drainage system. Corn and soybean cropping systems in tiled areas have been described as "leaking systems," losing 30 to 50 times more nitrate than perennial alfalfa and CRP grass/alfalfa systems (Randall, 2001).

Farm Nutrient Management Assessment Program for the South Branch of the Root River
(MDA Survey)

Cooperators

The South Branch Root River Project is a mutual effort by watershed farmers, landowners, citizens, county, state, and federal groups. The coalition interested in improving this watershed includes traditional water resource agencies: Soil and Water Conservation District (SWCD), Natural Resource Conservation District (NRCS), Environmental Services, Farm Service Agency (FSA), Minnesota Department of Agriculture (MDA), Minnesota Pollution Control Agency (MPCA) and Minnesota Department of Natural Resources (DNR).
This study focused on agricultural inputs (nutrients and pesticides) associated with the SBRR and summarizes the results of farm assessments conducted for the 2003 cropping season. A list of farmers/operators in the SBRR was obtained from the Fillmore and Mower SWCD and NRCS. Farm operations to be interviewed were chosen by random selection across each section.

Introduction letters describing the project were mailed to the farmers in January of 2004. 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.

The Minnesota Department of Agriculture (MDA) used a data-gathering tool and analysis system called the Farm Nutrient Management Assessment Program (FANMAP) to conduct the study. FANMAP was developed ten 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 decade, more than 800 farmers throughout Minnesota have volunteered one to three hours of their time to share information about their farming operations. Previous FANMAP studies have been conducted as a result of funding from programs such as the Legislative Commission on Minnesota Resources, Clean Water Partnership, and USDA programs and supplemental funding from the fertilizer tonnage fee account at the MDA. Previous reports can be found on the MDA website at http://www.mda.state.mn.us/appd/ace/fanmap.htm.

Nutrient Information of the Selected Farms in the South Branch Root River

Inventory forms and database design were patterned after a previous successful project[1]. The following types of information were collected on a field-by-field basis for all inventoried acres within the SBRR through FANMAP interviews:

- 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);
- Pesticide information (product, rate, timing, etc);
- Soil and manure testing results if available;
- Tillage practices.
- Sink holes and streams.

Livestock types, manure storage, application rates and application timing information was also recorded.

Nutrient inputs and yields were specific for the 2003 cropping season. Crop types and manure applications (starting in the fall of 2002) were also collected for the 2003 season for purposes of nitrogen crediting to crops grown during the 2003 season. 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.

Analysis was completed with the assistance of the SBRR Watershed Project. The focus of the analysis was determined though a SBRR Watershed Project meeting, including farmers, local residents and other persons attending.

Farm Size, Crop and Livestock Characteristics of the Selected Farms in the South Branch Root River

The sixty-one farm interviews were conducted between February and June of 2004. A total of 31,000 acres of farmland was inventoried in the SBRR study for the 2003 crop season. Fillmore County Farm Service Agency farm and tract information for the cropping year 2003 indicated there were approximately 74,000 acres in the SBRR. Farm interviews covered approximately 42% of all acres in the SBRR and 52% of all crop acres. Acres inventoried in Fillmore County totaled 22,300 and Mower County acres totaled 8,300. The SBRR watershed consists of 58,600 acres in Fillmore County and 15,700 acres in Mower County.

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

The SBRR cropland was dominated by a field corn/soybean rotation accounting for 82% of all acres. Figure 1 lists each type of crop grown and the corresponding percentage of acres.

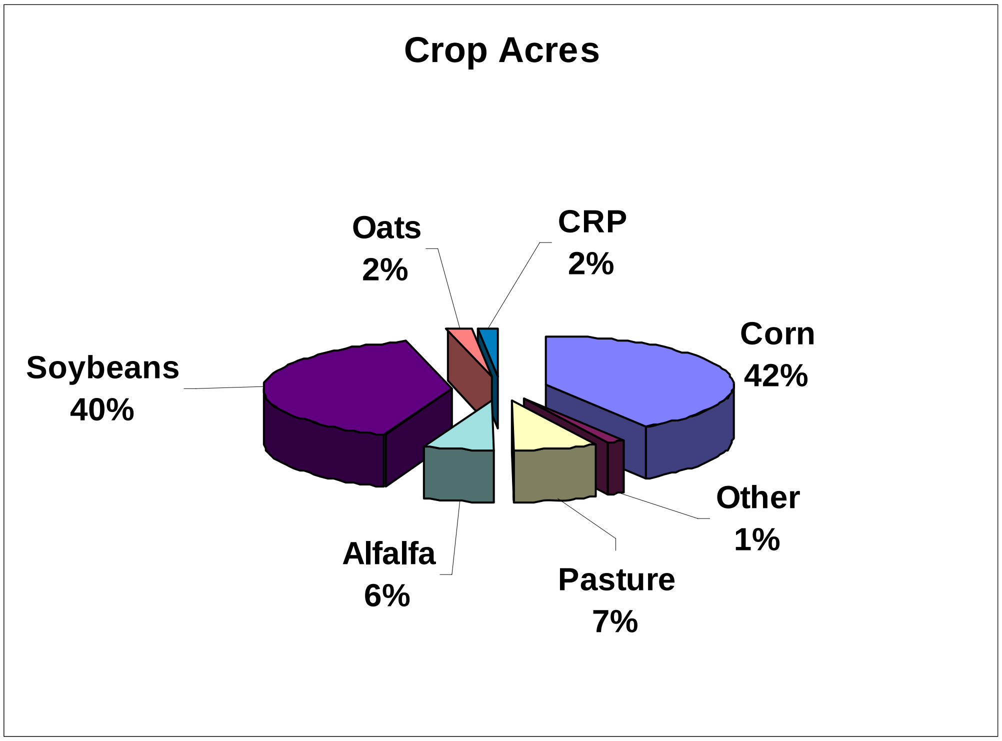


Figure 1. Crop types and corresponding percentages during the 2003 cropping season on 61 farms within the SBRR. Cropland totaled 30,593 acres.

Commercial Fertilizer Use Characteristics on Selected Farms: South Branch Root River

Commercial Nitrogen (N).

Field corn accounted for 97% (1,648,000) of the 1,704,000 pounds of commercial nitrogen (N) fertilizer applied on the 61 farms (Figure 2). Ninety-four (94%) of all field corn acres received commercial N fertilizer. All field corn acreage received either commercial N fertilizer or manure. Commercial N rates across all field corn acres averaged 135 lb/A. Total N inputs will be discussed later in the "Nutrient Balances and Economic Considerations" section of this report.

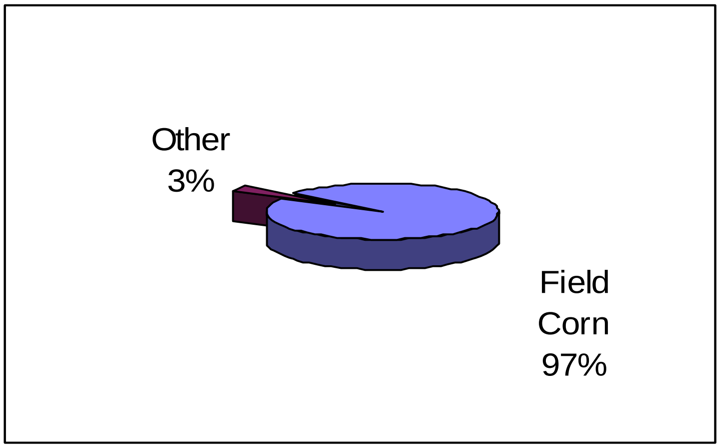


Figure 2. Commercial fertilizer N use by crop type. Commercial fertilizer N totaled 1,704,388 pounds.

Specific Best Management Practices for nitrogen use have been developed for southeast Minnesota[2]. Applications of nitrogen before spring planting of field corn are highly recommended in the SBRR. Fifty-seven (57%) of the N applied to field corn was as a spring pre-plant application (Figure 3).

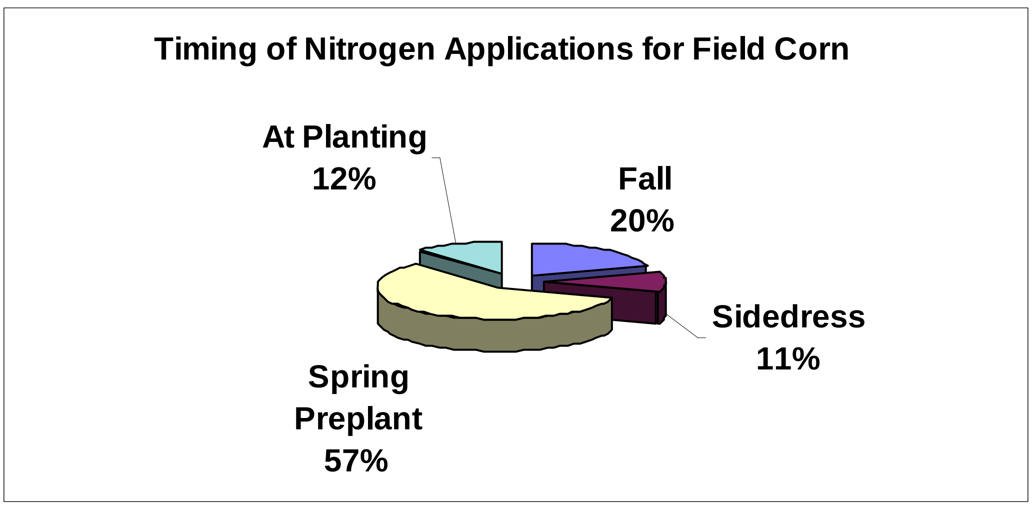
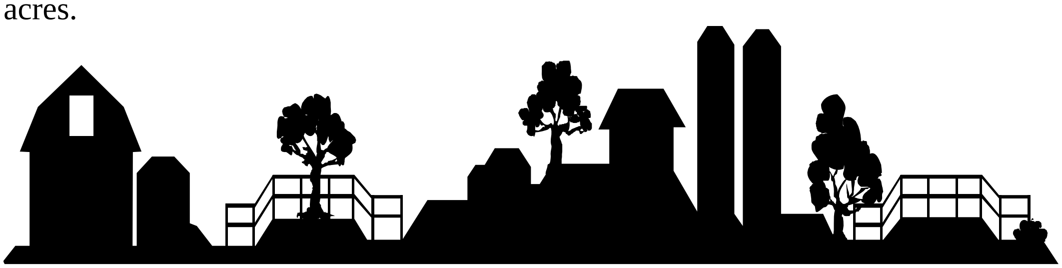


Figure 3. Timing of commercial N applications across all 12,585 inventoried **field corn** acres.



[2] Best Management Practices for Nitrogen Use in South-East Minnesota. M.A. Schmitt, G.W. Randall, University of Minnesota.

Urea supplied 36% of all commercial N on field corn acres (Figure 4).

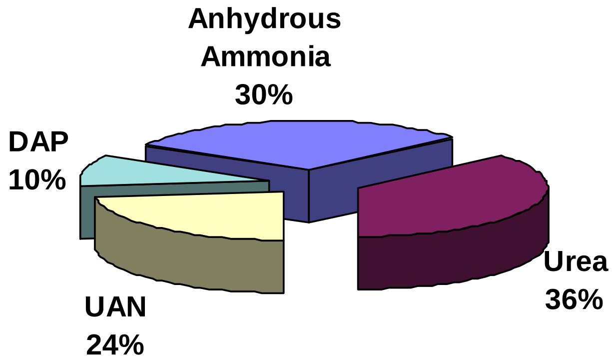


Figure 4. Sources of commercial N used on field corn acres[3].

Commercial N Applications on Field Corn

Ninety-four percent (94%) of the field corn received commercial nitrogen. Spring preplant accounted for over 50% of all nitrogen applied. Twenty percent (20%) of the N was fall-applied on corn acres (Table 1). Fall applications of Urea or Urea Ammonium Nitrate (UAN) solutions are not recommended. None of the growers were using fall-applied urea and fall applied N through UAN solutions was very limited. Fall applications of anhydrous ammonia are not recommended until the soil temperature reaches a consistent 50°, which generally occurs approximately November 1. According to the University of Minnesota fall applications of N are not recommended in Fillmore County and if fall applications of N are made in Mower County, it should be delayed until soils reach 50°. Thirty percent (30%) of the fall-applied anhydrous ammonia was applied in Mower County and the balance in Fillmore County. Ninety percent (90%) of fall-applied N in the form of anhydrous ammonia was applied after November 1. There was no use of nitrogen inhibitors in the SBRR. Urea was the dominant source of commercial N in spring pre-plant applications for field corn.

[3] Diamonium Phosphate is represented as DAP.

Table 1. Timing and Source of N on Field Corn Acres.		
Timing	**N Source**	**Pounds N**
Fall	Anhydrous Ammonia	245,625
Fall	Liquid Solutions	2,400
Fall	DAP	80,007
Spring Pre-plant	Anhydrous Ammonia	227,070
Spring Pre-plant	Urea	595,364
Spring Pre-plant	Liquid Solutions	62,600
Spring Pre-plant	DAP	55,125
At Planting	Urea	3,795
At Planting	Liquid Solutions	165,883
At Planting	DAP	28,591
Sidedress	Anhydrous Ammonia	24,630
Sidedress	Liquid Solutions	156,782
Totals	===	1,647,872

Commercial N Applications on Other Crops

A very small percentage (3%) of the commercial N was applied to crops other than corn.

Commercial Phosphorus.

There was 749,003 pounds of commercial P applied in 2003. Field corn accounted for more than 91% of the commercial phosphate fertilizer applied on the 61 farms (Figure 5). Ninety-five (95%) of all field corn acres received commercial phosphate fertilizer. Average commercial fertilizer rate of phosphate (P_2O_5) across all field corn acres was 54 lb/A. Total phosphate inputs will be discussed later in the "Nutrient Balances and Economic Considerations" section of this report.

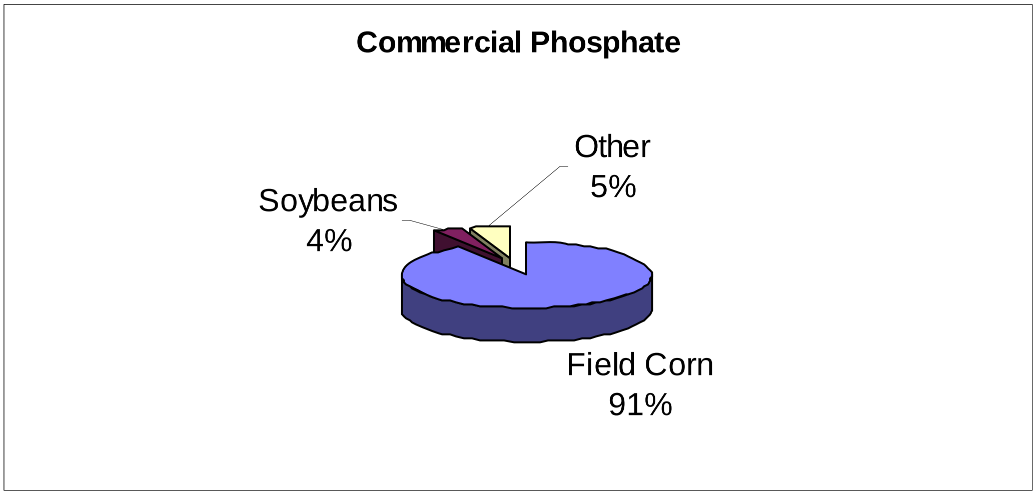


Figure 5. Destination of commercial phosphate used on all crop acres.

Forty-five percent (45%) of the commercial P was applied as a starter on inventoried field corn acres. Figure 6 details the timing of commercial P on field corn acres.

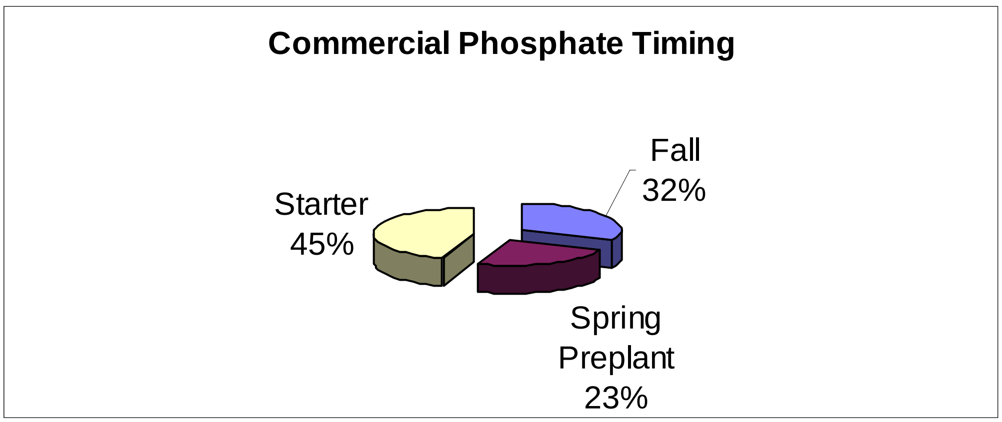


Figure 6. Timing of commercial phosphate applications across all **field corn** acres.

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. Livestock numbers in Table 3 represent the livestock inventory on hand from the fall of 2002 to the summer of 2003. It is assumed that the livestock manure generated during this time period was applied at some point in time to the 2003 crops. Twenty-six (26) of the 61 farmers interviewed had livestock in the SBRR.

Animal production on these farms consisted of dairy, beef, sheep, horse, and hog operations. Table 3 details the variety of animals raised in the SBRR.

Table 3. 2002 Distribution of Livestock Across Inventoried Farms	
Livestock Type	**Livestock Number**
Dairy Cows/bulls	484
Dairy Calves	533
Hog Finishers[4]	16,000
Beef Cows/bulls	873
Beef Calves/finishers	1,178
Sheep	1,096
Horses	15
TOTALS	**20,179**

Nutrients supplied though manure production totaled 519,000 pounds of N, 326,000 pounds of P and 431,000 pounds of K. However, all manure was not collected due to such scenarios as over-wintering on fields or use of pasture where manure is not collected. Manure production by type of livestock is listed in Table 4.

Table 4. Manure N P and K produced in the South Branch of the Root River by livestock type for the 2003 season.

	Nitrogen	**Phosphate**	**Potash**
Livestock Type			
Beef	215,688	162,190	188,442
Dairy	157,412	63,236	128,321
Hogs	134,400	96,000	104,000
Sheep/Horses	11,090	4,557	9,994
TOTALS	**518,590**	**325,983**	**430,757**

Although beef cattle produced the most manure in regards to nutrients, only 25% of the nutrients were collected. The balance of the manure that was not collected went on pastures or on fields where cattle were over-wintered. Currently there are no recommendations for crediting manure applied to fields from over-wintering.

Of the beef cattle manure that was collected, all was collected as a solid through barns or lots. Manure produced by hogs was collected as a liquid though manure pits. Dairy manure was collected though both liquid manure pits and solid systems of barns and lots. No manure was collected for spreading on crop acres from sheep and horses as these

[4] Hog finishers are the number sold per year. All other categories are average on hand per year.

animals were on pasture and manure applications were on pasture. Overall 29% of the manure based on N content was collected as solids and 71% was collected as liquids. Table 5 details the manure collected in the SBRR. Some of the manure collected was applied outside the watershed.

Table 5. Manure N and P collected to be spread on inventoried acres for the 2003 crop season.

	Nitrogen		Phosphate		Potash	
Livestock Type	**Nitrogen Produced**	**Nitrogen Collected**	**Phosphate Produced**	**Phosphate Collected**	**Potash Produced**	**Potash Collected**
Livestock Type						
Beef	215,688	54,333	162,190	40,867	188,442	47,753
Dairy	157,412	135,354	63,236	54,427	128,321	110,161
Hogs	134,400	134,400	96,000	96,000	104,000	104,000
Sheep/Horses[5]	11,090	0	4,557	0	9,994	0
TOTALS	**518,590**	**324,087**	**325,983**	**191,294**	**430,757**	**261,914**

Manure nutrient losses, especially manure N, can occur within a manure handling system though volatilization, leaching and runoff. Table 6 details the manure handling system losses for manure N. Except for minor losses of P and K on open lots, most of the P and K were retained in manure systems and was available to be spread on inventoried acres.

Table 6. Manure N collected and retained after manure handling system loses for the 2003 crop season.

	Nitrogen	
Livestock Type	**Nitrogen Collected**	**Nitrogen retained**
Livestock Type		
Beef	54,333	38,030
Dairy	135,354	99,500
Hogs	134,400	100,800
Sheep/Horses	0	0
TOTALS	**324,087**	**238,330**

[5] No manure was collected and spread on any fields other than pasture for both sheep and horses inventoried in the watershed.

Manure imported from outside the watershed was applied to 975 acres within the watershed. Field corn was grown on 797 of those acres with sweet corn and soybeans receiving imported manure on 178 acres total. All imported manure was hog manure and it was all in the liquid form. A total of 148,000 pounds of manure N, 84,000 pounds of P and 219,000 pounds of K was applied from imported manure on watershed acres. A small percentage of manure produced in the watershed was also applied outside the watershed.

Hog manure accounted for 71% of the first year available N applied though manure to inventoried acres. Table 7 further details the source of the nutrients, amounts of nutrients applied and nutrients available after application losses[6].

Table 7. Manure N and P spread on inventoried acres before and after application losses[7] for the 2003 crop season.

	Nitrogen		Phosphate		Potash	
Livestock Type	**Nitrogen Applied**	**Nitrogen Available**	**Phosphate Applied**	**Phosphate Available**	**Potash Applied**	**Potash Available**
Hog	217,208	173,366	136,335	109,068	273,363	246,027
Dairy	102,363	59,800	74,875	59,900	77,584	69,827
Beef	38,032	11,290	40,866	32,692	47,754	42,978
TOTALS	**357,603**	**244,456**	**252,076**	**201,660**	**398,701**	**358,832**

Manure was applied on 2,713 inventoried acres within the watershed. Manure was applied on 2,369 acres of corn and the balance on sweet corn, soybeans, alfalfa and oats. Table 8 details the manure applications on inventoried crop acres.

Table 8. Manure N P and K applied in the South Branch of the Root River by crop for the 2003 season.

	Acres	Nitrogen	Phosphate	Potash
Crop Type				
Corn	2,369	208,389	173,159	290,450
Soybeans	128	9,033	5,845	7,899
Sweetcorn	101	15,514	10,342	45,813
Alfalfa	63	5,800	8,154	9,989
Oats	52	5,721	4,161	4,681
TOTALS	**2,713**	**244,457**	**201,661**	**358,832**

[6] In most instances liquid manure was applied with a known manure test. Because of instances where more or less than one year of manure is applied, as April one year and March of the following year, manure applications of nutrients based on manure tests do not always match manure nutrients retained and available for spreading as listed in tables 5, 6 and 7.

[7] Application losses based on Livestock Waste Facilities Handbook.

Seventy-two percent (72%) of the first year available N was applied in the fall on inventoried acres in the SBRR (Figure 7).

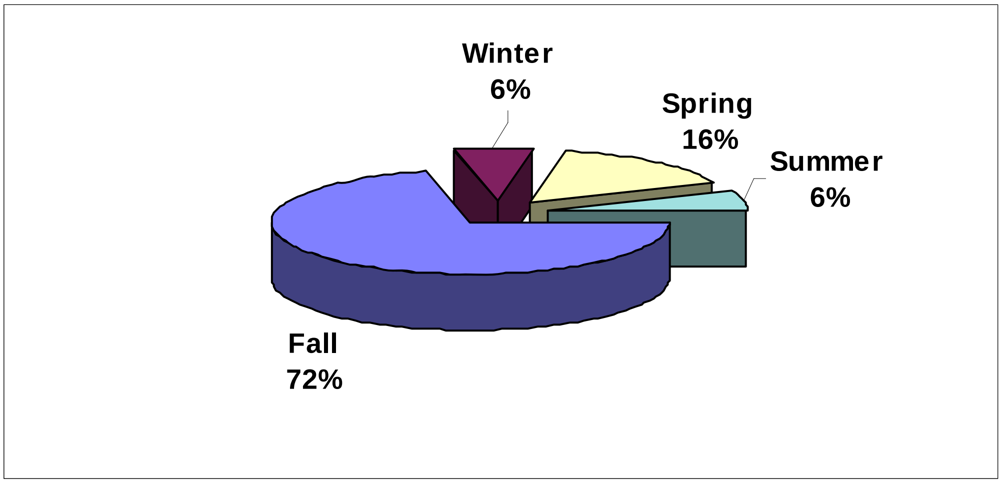


Figure 7. Timing[8] of first year available manure N on inventoried acres in the SBRR. Manured acres totaled 2,739 of which 2,369 acres were corn.

Manure applications on inventoried corn acres consisted of injection, broadcast with no incorporation and broadcast with incorporation (Figure 8).

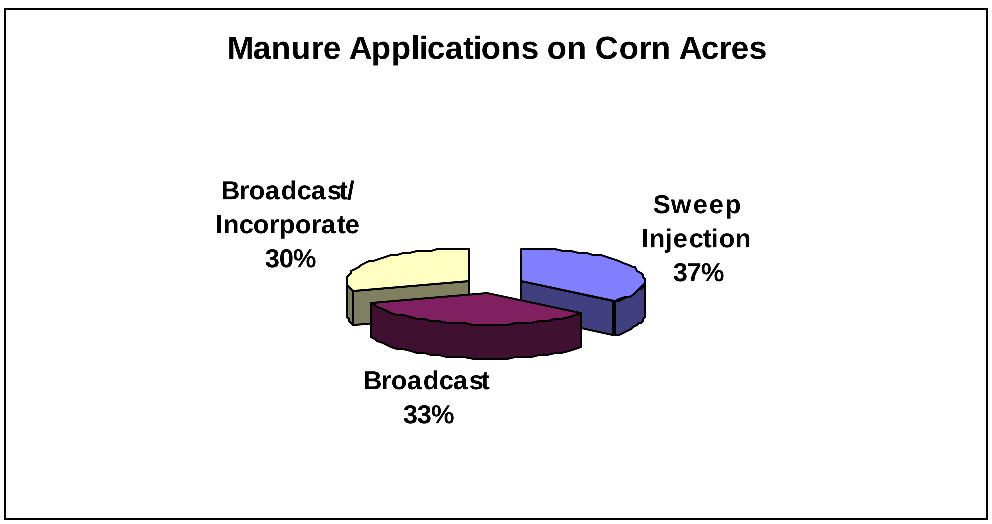


Figure 8. Application methods of manure applications on inventoried corn acres in the SBRR.

[8] Timing based on pounds of N available to the 2003 crop.

Livestock in the SBRR produce manure in different quantities by livestock type and size of the livestock. Nutrient values also differ across livestock type and size of the livestock. On surveyed farms, beef manure contributed the largest percentage of N produced by livestock type (Figure 9).

However, due to the addition of imported hog manure into the SBRR, lack of collection of beef manure from time on pastures and over-wintering on fields, and the lack of incorporation of beef manure, hogs contributed the largest percentage of 1st year available N. Figure 10 is the actual portion of N from manure that is applied to fields in the SBRR and available for the crop by livestock type.

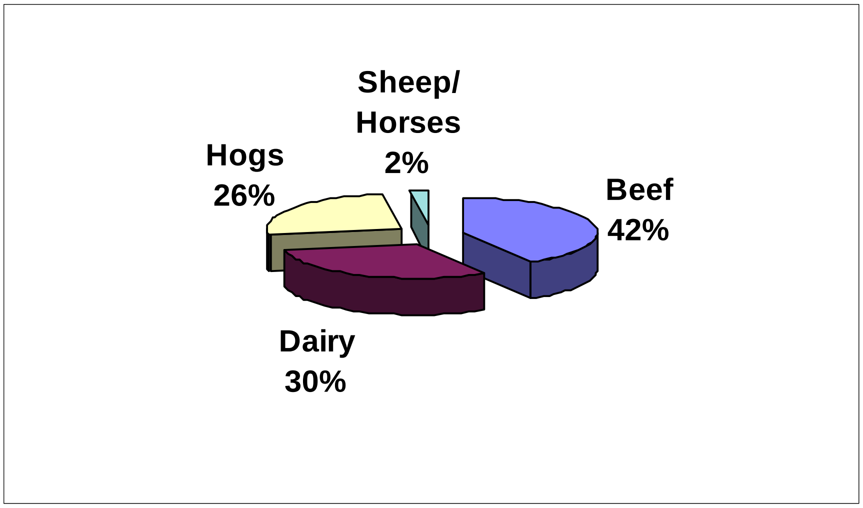


Figure 9. Manure N production of livestock by type within the SBRR.

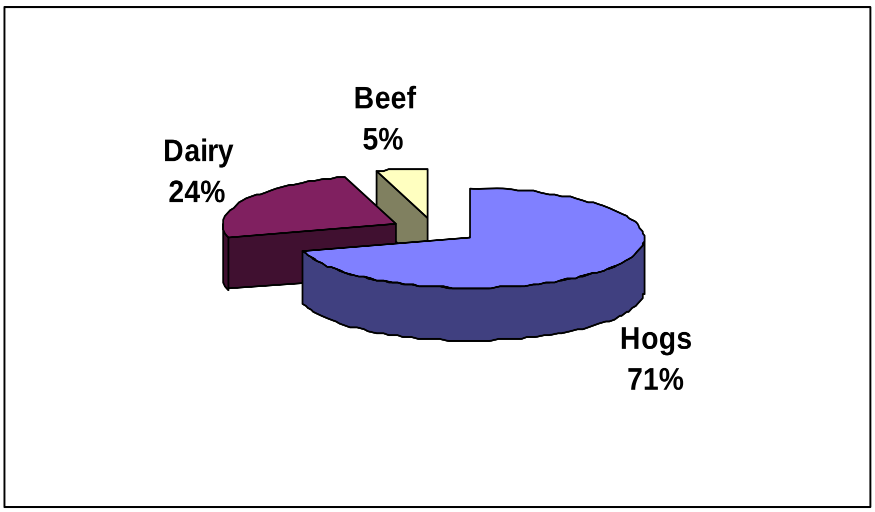


Figure 10. Manure 1st year available N for surveyed acres by livestock type.

Generally beef manure is hauled on a yearly basis or in some instances with less frequency. More frequent manure hauling may increase recapture of nutrients and may reduce runoff in these instances.

Relative Importance of Nutrient Sources on the Selected Farms: South Branch Root River

Commercial N applications accounted for 87% of the total N applied on inventoried corn acres with the balance of N contributed from manure. A total of 1,949,000 pounds of N were applied on inventoried fields. Corn acres received 1,856,262 pounds with the balance applied to acres other than corn. Table 9 details the contributions of N, P and K from both manure and commercial N applied to the various inventoried crops.

Table 9. Total N P and K applied in the South Branch of the Root River by crop for the 2003 season.

	Acres	Nitrogen	Phosphate	Potash
Crop Type				
Corn	12,585	1,856,262	854,536	1,390,803
Soybeans	12,272	20,037	33,703	59,369
Sweetcorn	101	15,513	10,342	45,814
Alfalfa	1,908	18,588	17,584	121,219
Oats	674	11,754	7,610	13,610
Other	3,053	23,554	26,888	68,480
TOTALS	**30,593**	**1,948,845**	**950,664**	**1,699,295**

It is important that producers recognize and take the appropriate N credit for past legume crops. The UM recommendations for corn are reduced anywhere from 75-100 pounds N per acre for alfalfa dependent on the alfalfa stand and 40 pounds N per acre or more for soybeans, dependent on yield. In this study alfalfa was the previous crop to corn on 300 acres. Based on the stand density the first year alfalfa credit given was 75 pounds N per acre. Alfalfa credits for second year were available on 343 acres at 50 pounds N per acre. Soybeans, the most important source of legume N in this study, supplied 40 pounds of N per acre to all inventoried corn acres previously in soybeans in 2002.

Commercial fertilizers (73%), manures (9%), and legumes (18%) contributed a total of 2,264,000 lb of "first year available N" to all inventoried corn acres in 2003 (Figure 11).

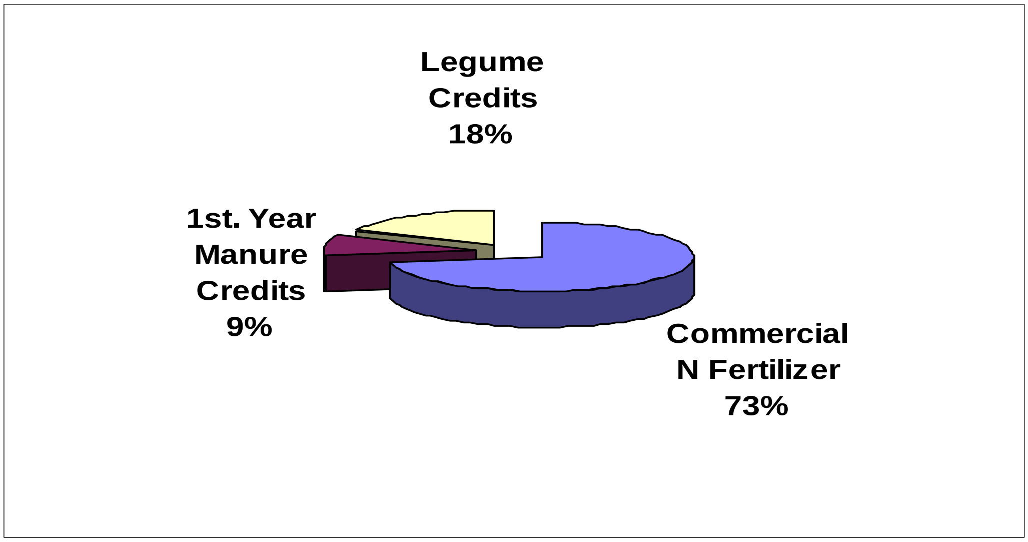


Figure 11. Relative N contributions from fertilizers, manures and legumes across all **corn** acres inventoried in 2002. Nitrogen inputs totaled 1,856,000 lb for all sources applied across all inventoried corn acres. Legume credits (407,650 pounds) are reflected in UM recommendations and are not considered an input.

Nutrient Balances and Economic Considerations: South Branch Root River

Nitrogen Contributions

Contributions of N from commercial fertilizer and manure to inventoried acres totaled 1,949,000 pounds. Field corn received most of the N with 95% (1,856,000 pounds of N) of the total N applied. Field corn yield goal across these farms averaged 161 Bu/A and were highly consistent with historic yield averages of 157 Bu/A for the past five years. It appears farmers are using realistic yield goals for field corn acres and it also appears that farmers have been growing excellent crops to reach their yield goals consistently in the past five years.

University of Minnesota recommendations are based on economic and environmental factors. Research at the Southern Minnesota Research & Outreach Center (Waseca) has shown that the recommendations are based on sound economic decisions and, in the long term, generally optimize profit.

University of Minnesota (UM) 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. This analysis compares actual amounts of N with the current recommendations.

Current UM N recommendations for field corn across all inventoried acres averaged 130 lb N/A. Actual amounts of N applied from fertilizer and manure averaged 147 lb N/A across all corn acres (Figure 12). Factoring in all appropriate credits from fertilizer, legumes and manures, there was an over-application rate of 17 lb/N/A according to current UM recommendations.

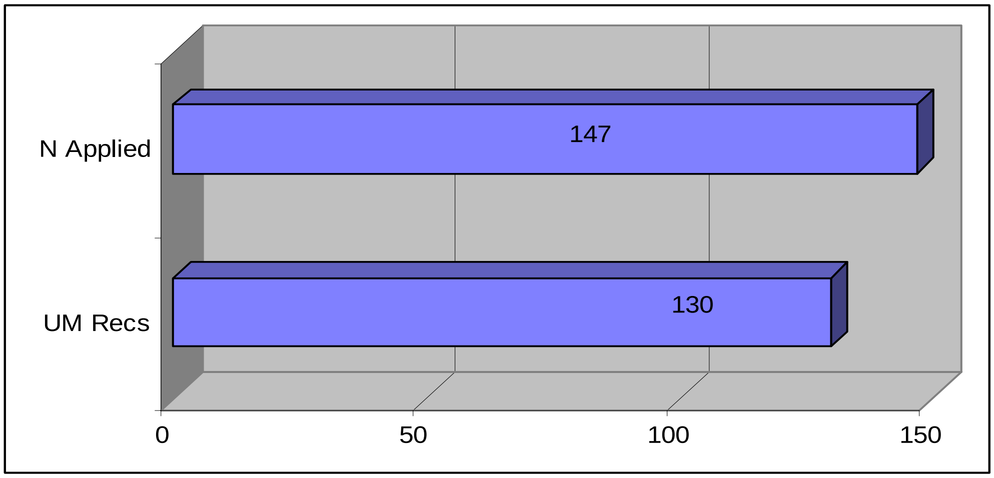


Figure 12. 2003 crop N requirements based on University of Minnesota nitrogen recommendations in comparison to actual N inputs (fertilizer and manure) for field corn acres in the inventoried area. Average N application was 147 lb N/A.

Figure 13 details corn fields without manure and Figure 14 details corn fields with manure.

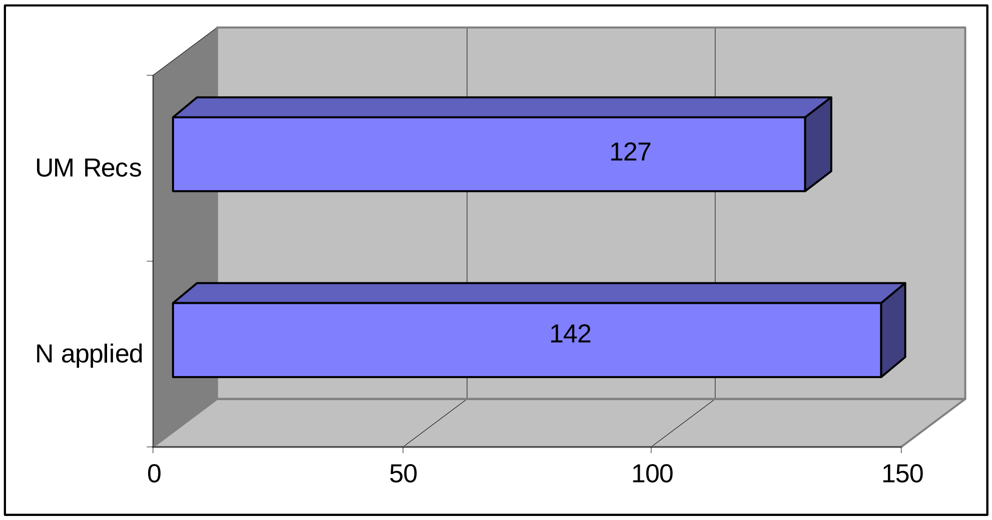


Figure 13. 2003 crop N requirements based on University of Minnesota nitrogen recommendations in comparison to actual N inputs (fertilizer and manure) for field corn acres **not** applied with manure.

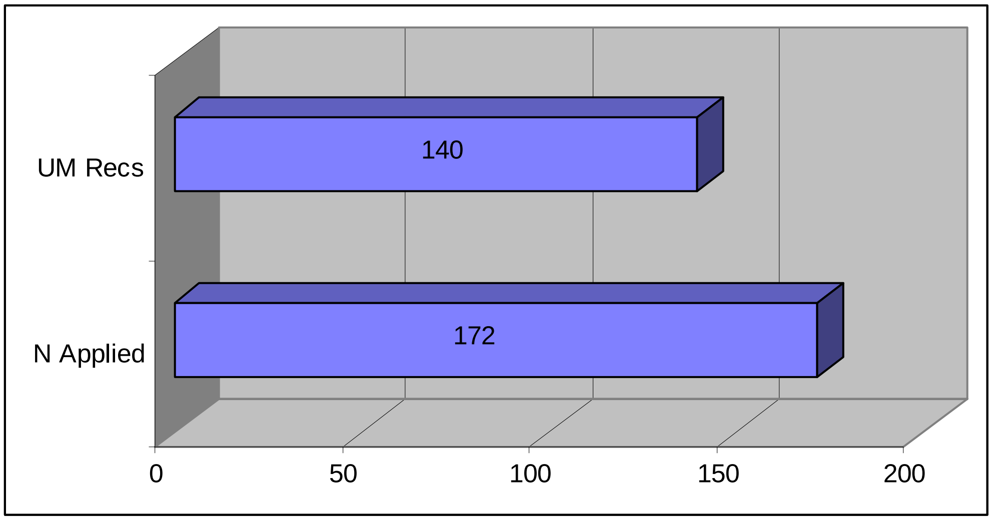


Figure 14 2003 crop N requirements based on University of Minnesota nitrogen recommendations in comparison to actual N inputs (fertilizer and manure) for field corn acres applied with manure.

One major advantage 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.

Yields and yield goals varied widely across the watershed. Table 10 details N applications by yield goal and Table 11 details N applications by yield goal and manure applications.

Table 10. Corn Acres and N Applied by Yield on the South Branch of the Root River for the 2003 season.

	Acres	N Applied	N Recom-mended	Over Application
Yield Goal				
100 – 149	1,032	89	83	7
150 – 174	8,842	145	130	15
175 or Higher	2,711	178	145	33
Totals/ Average	**12,585**	**147**	**130**	**17**

Table 11. Corn Acres and N Applied by Yield and Manure Applications on the South Branch of the Root River for the 2003 season.				
	Acres	**N Applied**	**N Recom-mended**	**Over Application**
Yield Goal				
100 – 149 No Manure	948	94	83	11
100 – 149 Manure	84	40	81	-41
150 – 174 No Manure	7,498	143	129	14
150 – 174 Manure	1,344	154	136	18
175 or Higher No Manure	1,700	161	142	19
175 or Higher Manure	1,011	207	151	57
Totals/ Average	**12,585**	**147**	**130**	**17**

Figures 15 and 16 details how close farmers were to the University of Minnesota recommendations in regard to nitrogen applications.

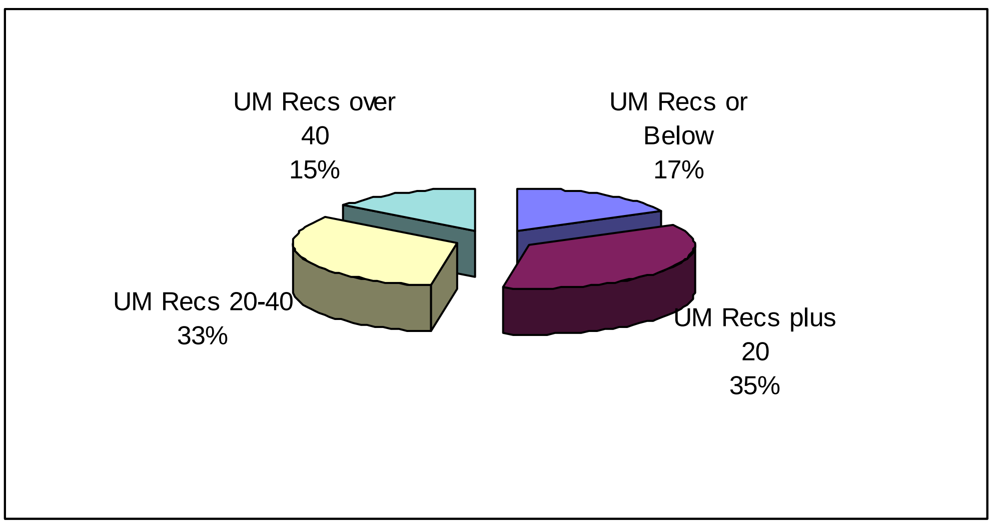


Figure 15. distribution of corn fields within and above the University of Minnesota recommendations for N.

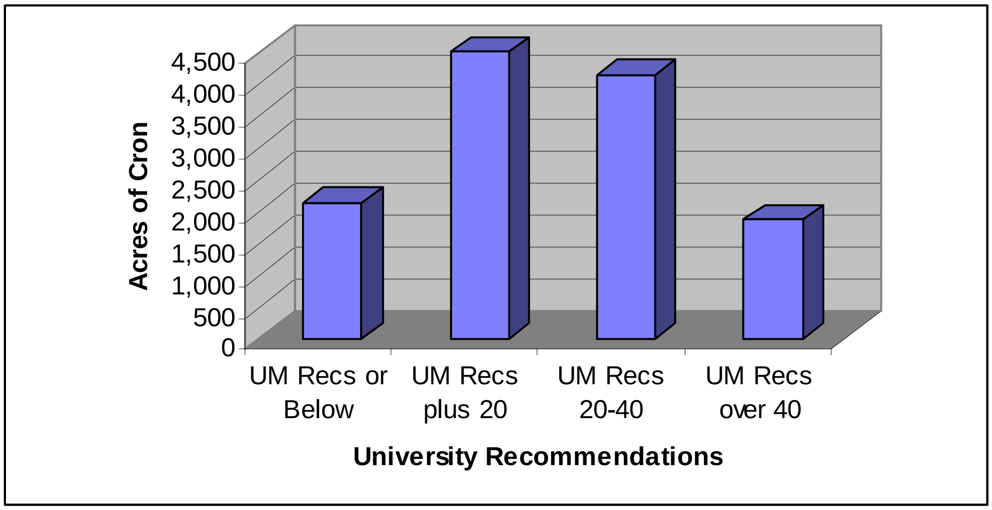


Figure 16. Acres of corn within and above the University of Minnesota recommendations for N.

Table 12 details manure applications on corn fields by manure type and over-application. Corn acres applied with hog manure have greater over-application of N for farmers in the SBRR when compared to other corn acres applied with livestock manure.

Table 12. Corn Acres and N Applied by Manure Type on the South Branch of the Root River for the 2003 season.

	Acres	N Applied	N Recom-mended	Over Application
Manure Type				
Dairy	480	143	147	-4
Beef	818	134	130	5
Hog	1,071	216	146	69
Totals/Averages	**2,369**	**172**	**140**	**32**

Table 13 details corn acres and N applications by county.

Table 13. Corn Acres and N Applied by County on the South Branch of the Root River for the 2003 season.

	Acres	N Applied	N Recommended	Over Application
County				
Fillmore	9,432	142	128	14
Mower	3,153	164	135	29
Totals/Averages	**12,585**	**147**	**130**	**17**

Table 14 details corn N applications by previous crop.

Table 14. Corn Acres and N Applied by Previous Crop on the South Branch of the Root River for the 2003 season.				
	Acres	**N Applied**	**N Recom-mended**	**Over Application**
Crop Rotation				
Corn/Soybeans	9,200	151	126	25
Corn/Alfalfa[9]	643	58	63	-5
Corn/Corn or Other	2,742	157	158	-1
Totals/Averages	**12,585**	**147**	**130**	**17**

Phosphorus Contributions

Contributions of P from commercial fertilizer and manure to inventoried acres totaled 951,000 pounds. Field corn received most of the P with 90% (855,000 pounds) of the total P applied.

Thirteen percent (13%) of the acres inventoried had soil tests available at the time of the interview. Soil tests were from the previous three years. Soil tests were all Bray except one Olsen and were converted to categories listed in Figure 17 of low through very high. There were no soils that were very low in P. Although many more farmers may have had soil tests, availability at the time of the survey was limited. Farmers were not required to due extensive looking for a soil test. Soil tests are valid for 4 years and were not always located with current farmer records.

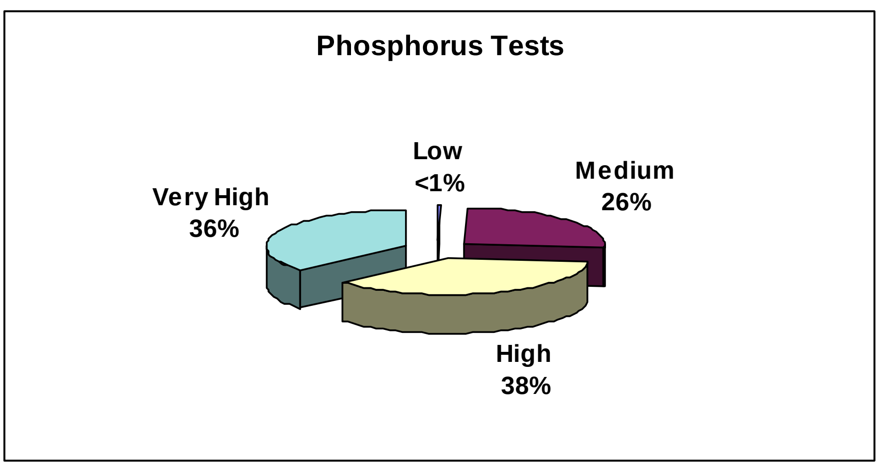


Figure 17. Percentage of acres in each soil testing P category across inventoried acres.

[9] Corn/Alfalfa includes all acres of corn following alfalfa and also corn following alfalfa the second year.

According to the Potash & Phosphate Institute[10], the percentage of soils testing medium or less for P within a state ranges from 15 to 86%. In Minnesota for the year 2001, 47% of the soil P tests were medium or below. On inventoried acres, 27% of the soil tests were medium or below. The UM recommendations for P vary widely by crop and by soil test, tillage, and placement. In addition the UM recognizes special considerations for applications of P[11]. Another factor is individual manure management plans may be based on N in the manure. These plans may require applications of P greater than the amount of P the UM would recommend without manure applications. Because of all of these factors, comparisons of actual amounts of P applied cannot be compared to UM recommendations as was done with N. However it does appear that rates for P could be reduced in many instances, especially when the P soil tests are in the high and very high ranges.

Phosphorus applications to inventoried field corn averaged 68 lb/A (54 lb/A from commercial P and 14 lb/A from manure applications). Crop removal of P can also be determined according to UM calculations. Corn grown on inventoried acres averaged 161 bushels per acre. Crop removal would be calculated at 56 lb/A per year for corn[12]. Soybeans grown on inventoried acres averaged 45 bushes per acre over the last 5 years. Crop removal would be calculated at 41 lb/A per year for soybeans. Seventy-three percent (73%) of the acres were in a corn/soybean rotation. Over a two year rotation, 68 lb of phosphate would be applied and 97 lb phosphate would be removed. If this practice continues, the soil P tests may drop, on average, by .4 to .8 ppm P/yr[13]. Inventoried farmers could reduce phosphate applications in many cases, but overall, are still applying less than crop removal in this survey. In the case of acres applied with manure, P buildup, on average, is occurring on some acres.

Table 15 details the phosphorus applications by manure applications.

Table 15. Corn Acres and P Applied by Manure Applications on the South Branch of the Root River for the 2003 Season.

Manure Applied	Acres	P Applied	P Average per Acre
Corn Acres Manure	2,369	247,546	104
Corn Acres No Manure	10,216	606,990	59
Totals/Averages	**12,585**	**854,536**	**68**

[10] Nutrient Budgets in North America, P. E. Fixen, A. M. Johnston.
[11] Fertilizing corn in Minnesota, G. Rehm, J. Lamb, R. Eliason, M. Schmitt, G. Randall, University of Minnesota.
[12] Nutrient Removal by Major Minnesota Crops, G. Rehm, University of Minnesota.
[13] Soil Test P: How Fast Does it Change?, G. Randall, T Iragavarapu, University of Minnesota.

Manured corn acres received an average of 87 pounds of N and 72 pounds of P per acre through manure applications. Total N and P applied on those manured corn acres were 172 and 104 pounds per acre respectively.

Tiled Acres:
South Branch Root River

Limited information was also gathered on tiled acres within the SBRR. Highlights include:

1. Only 2 tile intakes located within fields. Many intakes were located in the roadside ditches, and often provided backflow relief.
2. There were 14,276 tiled acres. These acres were the amount of actual acres drained as opposed to the total of fields with some tile drainage. HEL acres totaled 5,600 across the watershed.
3. There were 62 sink holes located within the farms interviewed. These sink hole locations included pasture and sink holes located in areas other than fields on the farms.
4. Within the SBRR, 27 fields have streams and 13 of those have some buffer. There were 291 fields in the survey.

Tillage Practices:
South Branch Root River

Tillage practices were documented on all surveyed acres in the SBRR. Field corn acres were dominated by a variety of tillage equipment passes, including chisel, ripper, and cultivators that generally left a minimum of 30% residue after tillage (Figure 18). The Chisel/Ripper/Cultivator category includes fields with primary tillage of chisel plow, soil finisher, disc ripper, field cultivator and soil saver types of equipment. Generally this category included fields with more than one pass of tillage equipment.

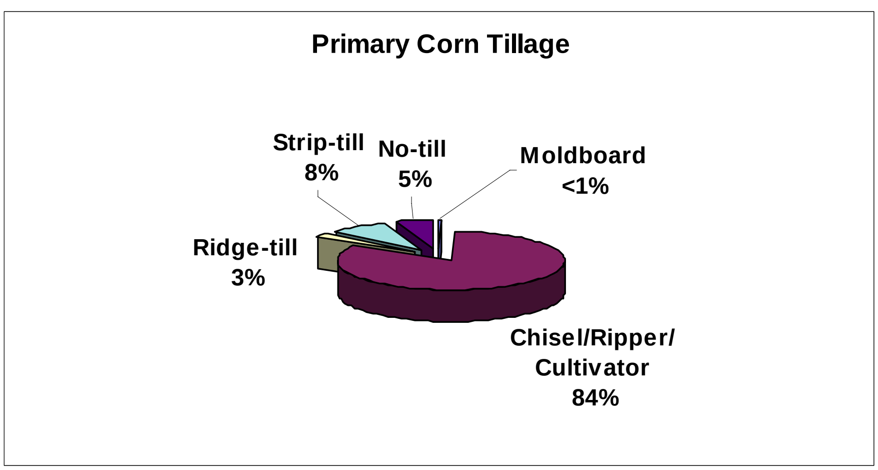


Figure 18. Percentage of acres in each tillage category across inventoried corn acres.

Soybean acres were also dominated by the Chisel/Ripper/Cultivator category, although a high percentage of the acres were also no-till (Figure 19).

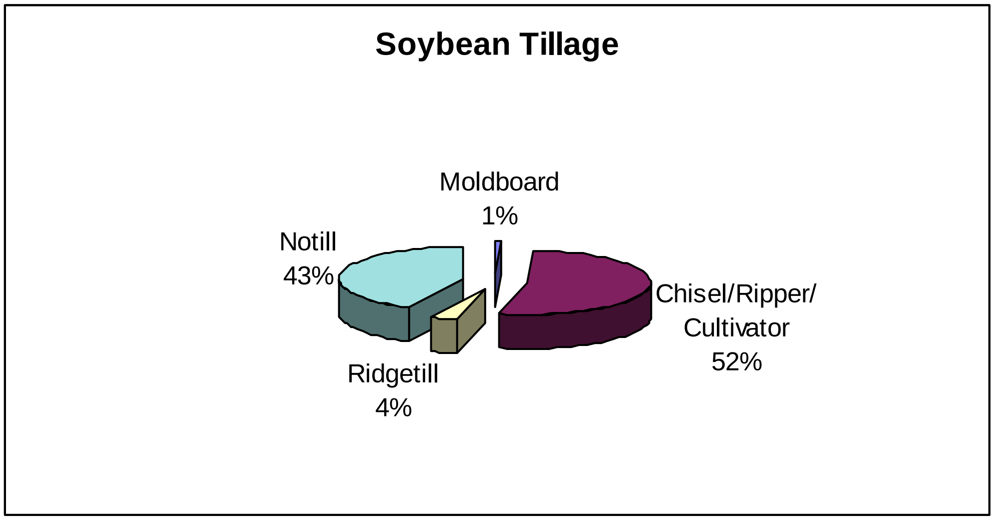


Figure 19. Percentage of acres in each tillage category across inventoried soybean acres.

Oats, seeded alfalfa and pea fields totaled 900 acres. Of these acres 500 were tilled with a field cultivator (Figure 20).

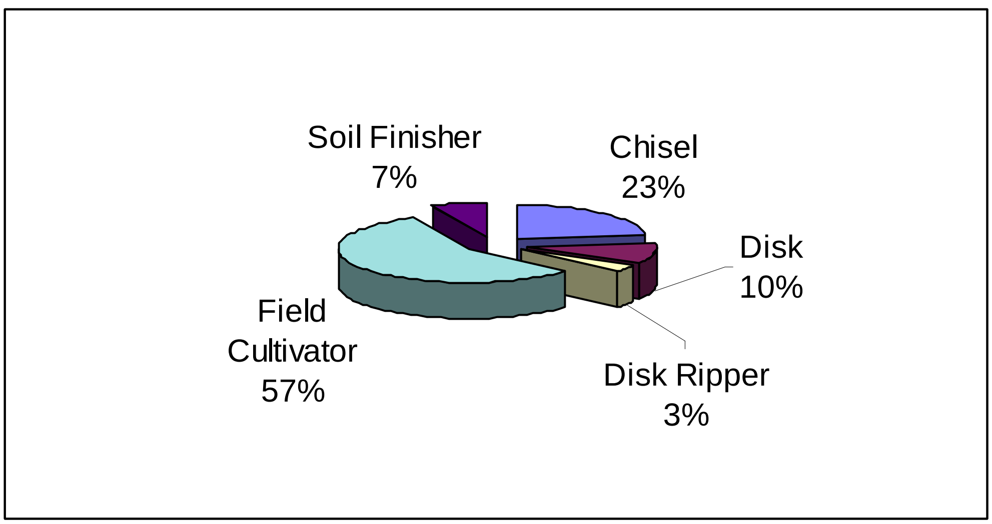


Figure 20. Percentage of acres in each tillage category across inventoried miscellaneous acres.

Pesticide Applications:
South Branch Root River

Pesticide use data was gathered on all inventoried crop acres. Pesticides were used on 81% of all inventoried crop acres (Table 16). Pesticide use in the SBRR included only herbicides and insecticides.

Table 16. Inventoried Crop Acreage and Percentage Treated With Pesticides.

Crop Grown	Total Acres	Pesticides	
		Acres Treated	Percent of Total Acres
Corn	12,585	12,121	97%
Soybeans	12,272	12,034	98%
Other	5,736	617	11%
Total Acres	**30,593**	**24,772**	**81%**

Pesticide use on all acres consisted of 58 different formulas (different EPA numbers, or products). Table 17 describes the pesticide, product used and the corresponding Active Ingredients (AI) of each pesticide product used.

Table 17. Product Name and Description of Pesticide Use in SBRR.					
Name Of Product	**EPA Number**	**Herbicide Insecticide**	**Active Ingredients (AI)**	**AI in Product**	**AI Expressed as**
Aatrex 4l	100-497	Herbicide	Atrazine	4.00	Pounds Per Gallon
Aatrex 9o	100-585	Herbicide	Atrazine	0.90	Percent by Weight
Accent	352-560	Herbicide	Nicosulfuron	0.75	Percent by Weight
Accent Gold	352-593	Herbicide	Clopyralid Flumetsulam Nicosulfuron Rimsulfuron	0.52 0.19 0.07 0.07	Percent by Weight
Aim	279-3194	Herbicide	Carfentrazone Ethyl	0.40	Percent by Weight
Asana Xl	352-515	Insecticide	Esfenvalerate	0.66	Pounds Per Gallon
Assure Ii	352-541	Herbicide	Quizalofop P Ethyl	0.88	Pounds Per Gallon
Atrazine 90 Wdg	34704-622	Herbicide	Atrazine	0.90	Percent by Weight
Authority	352-590	Herbicide	Sulfentrazone	0.75	Percent by Weight
Aztec 2	3125-412	Insecticide	Cyfluthrin Tebupirimphos	0.00 0.02	Percent by Weight
Banvel	51036-289	Herbicide	Dicamba	4.00	Pounds Per Gallon
Boundary	100-958	Herbicide	Metribuzin S-Metolachlor	1.50 6.30	Pounds Per Gallon
Buctril	264-437	Herbicide	Bromoxynil	2.00	Pounds Per Gallon
Callisto	100-1131	Herbicide	Mesotrione	4.00	Pounds Per Gallon
Celebrity Plus	7969-175	Herbicide	Dicamba Diflufenzopyr Nicosulfuron	0.47 0.18 0.11	Percent by Weight
Cinch	87392-12-9	Herbicide	S-Metolachlor	7.64	Pounds Per Gallon
Clarity	7969-137	Herbicide	Dicamba	4.00	Pounds Per Gallon
Classic	352-436	Herbicide	Chlorimuron-Ethyl	0.25	Percent by Weight
Distinct	7969-150	Herbicide	Dicamba Dichloro O Anisic Acid	0.21 0.55	Percent by Weight
Dual Ii	100-711	Herbicide	S-Metolachlor	0.84	Percent by Weight
Dual Ii Magnum	100-818	Herbicide	S-Metolachlor	7.64	Pounds Per Gallon
Extreme	241-405	Herbicide	Glyphosate Imazethapyr	2.00 0.17	Pounds Per Gallon
First Rate	62719-275	Herbicide	Cloransulam-Methyl	0.84	Percent by Weight
Flexstar	10182-418	Herbicide	Fomesafen	1.88	Pounds Per Gallon
Force 3g	100-1075	Insecticide	Tefluthrin	0.03	Percent by Weight
Fusion	10182-343	Herbicide	Fenoxaprop-P-Ethyl	0.56	Pounds Per Gallon
			Fluazifop-P-Butyl	2.00	
Glyphosate	352-607	Herbicide	Glyphosate	4.00	Pounds Per Gallon
Harmony Gt	352-446	Herbicide	Thifensulfuron	0.75	Percent by Weight
Harness	524-473	Herbicide	Acetochlor	7.00	Pounds Per Gallon
Harness 20g	524-487	Herbicide	Acetochlor	0.20	Percent by Weight
Harness Extra	524-480	Herbicide	Acetochlor Atrazine	4.30 1.70	Pounds Per Gallon
Hidep	2217-703	Herbicide	2,4-D	3.80	Pounds Per Gallon
Hornet	62719-253	Herbicide	Clopyralid Flumetsulam	0.63 0.23	Percent by Weight
Keystone	62719-368	Herbicide	Acetochlor Atrazine	3.00 2.25	Pounds Per Gallon
Keystone La	26719-479	Herbicide	Acetochlor Atrazine	4.00 1.50	Pounds Per Gallon
Liberty	45639-199	Herbicide	Glufosinate-Ammonium	1.67	Pounds Per Gallon
Lightning	241-377	Herbicide	Imazapyr Imazethapyr	0.18 0.53	Percent by Weight
Lorsban-4e	62719-220	Insecticide	Chlorpyrifos	4.00	Pounds Per Gallon
Lumax	100-1152	Herbicide	Atrazine Mesotrione S-Metolachlor	1.00 0.27 2.68	Pounds Per Gallon
Northstar	100-923	Herbicide	Dicamba Primisulfuron	0.40 0.08	Percent by Weight
Outlook	7969-156	Herbicide	Dimethenamid	6.00	Pounds Per Gallon
Pursuit	241-310	Herbicide	Imazethapyr	2.00	Pounds Per Gallon
Pursuit Plus Ec	241-331	Herbicide	Imazethapyr Pendimethalin	0.20 2.70	Pounds Per Gallon
Python Wdg	62719-277	Herbicide	Flumetsulam	0.80	Percent by Weight
Raptor	241-379	Herbicide	Imazamox	1.00	Pounds Per Gallon
Regent	7969-207	Insecticide	Fipronil	4.00	Pounds Per Gallon
Roundup Ultra	524-475	Herbicide	Glyphosate	3.00	Pounds Per Gallon
Roundup Ultra Max	524-512	Herbicide	Glyphosate	4.00	Pounds Per Gallon
Roundup Weathermax	524-537	Herbicide	Glyphosate	5.50	Pounds Per Gallon
Select 2ec	59639-3	Herbicide	Clethodim	2.00	Pounds Per Gallon
Steadfast	352-608	Herbicide	Nicosulfuron Rimsulfuron	0.50 0.25	Percent by Weight
Sterling Plus	51036-307-9779	Herbicide	Atrazine Dicamba	2.10 1.10	Pounds Per Gallon

Table 17 (Continued). Product Name and Description of Pesticide Use in SBRR.					
Name Of Product	**EPA Number**	**Herbicide Insecticide**	**Active Ingredients (AI)**	**AI in Product**	**AI Expressed as**
Surpass 100	10182-363	Herbicide	Acetochlor Atrazine	3.00 2.00	Pounds Per Gallon
Surpass Ec	10182-325	Herbicide	Acetochlor	6.40	Pounds Per Gallon
Touchdown	10182-449	Herbicide	Glyphosate	3.00	Pounds Per Gallon
Treflan Hfp	62719-250	Herbicide	Trifluralin	4.00	Pounds Per Gallon
Tri-4 Hf	241-343	Herbicide	Trifluralin	4.00	Pounds Per Gallon
Warrior	10182-96	Insecticide	Lambda-Cyhalothrin	1.00	Pounds Per Gallon

There were a total of 49,026 pounds of active ingredients (AI) from all pesticides used on all crops. Herbicide AI totaled 46,273 pounds and insecticide AI totaled 2,753 pounds. There were no fungicides applied on inventoried acres. Field corn acres accounted for 63% of all pesticide AI use by pounds (Figure 21).

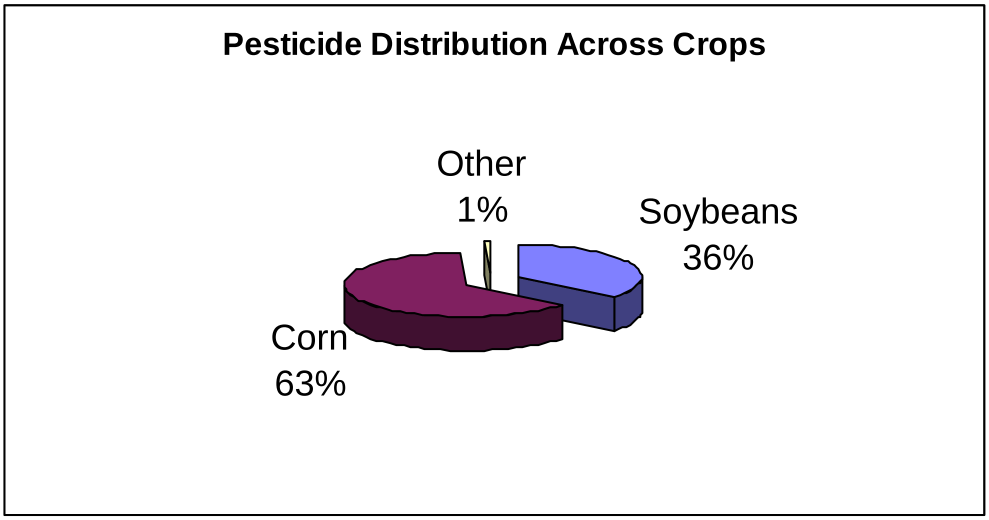


Figure 21. Application of pesticide AI's applied to inventoried acres by crop type and percentage of pounds applied.

Table 18 lists each AI, coverage and total pounds for the 40 different AI's applied to inventoried acres.

Table 18. Pesticide Use And Acres Treated by Active Ingredient.

Name Of Compound	Acres Treated	Total Pounds Applied
2,4-D	1,938	932
Acetochlor	5,970	11,464
Atrazine	10,226	7,597
Bromoxynil	378	94
Carfentrazone Ethyl	104	<1
Chlorimuron-Ethyl	93	<1
Chlorpyrifos	5,091	2,545
Clethodim	83	6
Clopyralid	2,394	288
Cloransulam-Methyl	83	1
Cyfluthrin	367	2
Dicamba	2,619	702
Dichloro O Anisic Acid	739	101
Diflufenzopyr	264	13
Dimethenamid	997	929
Esfenvalerate	344	11
Fenoxaprop-P-Ethyl	956	22
Fipronil	221	28
Fluazifop-P-Butyl	956	81
Flumetsulam	2,537	113
Fomesafen	1,657	419
Glufosinate-Ammonium	612	204
Glyphosate	11,884	14,484
Imazamox	401	15
Imazapyr	341	4
Imazethapyr	1,684	75
Lambda-Cyhalothrin	3,276	76
Mesotrione	2,556	296
Metribuzin	175	38
Nicosulfuron	2,376	52
Pendimethalin	24	16
Primisulfuron	200	2
Quizalofop P Ethyl	435	12
Rimsulfuron	1,912	22
S-Metolachlor	3,145	7,391
Sulfentrazone	360	67
Tebupirimphos	367	50
Tefluthrin	324	38
Thifensulfuron	1,260	2
Trifluralin	1,186	813

Pesticide use on corn acres consisted of 25 separate herbicide AI's. Table 19 details each compound used and the number of acres treated by each compound.

Table 19. Pesticide Use on Corn Acres.

Name Of Active Ingredient	Percent Of All Surveyed Corn Acres	Rate Applied Pounds per Acre Per Year	Total Acres Treated	Total Pounds Applied	Percent of Total AI Applied to Surveyed Corn Acres
2,4-D	6%	0.46	759	347	1%
Acetochlor	47%	1.92	5,970	11,464	37%
Atrazine	80%	0.75	10,125	7,552	24%
Bromoxynil	3%	0.25	378	94	0%
Carfentrazone Ethyl	1%	0.01	104	1	0%
Chlorpyrifos	1%	0.50	150	75	0%
Clopyralid	19%	0.12	2,394	288	1%
Cyfluthrin	3%	0.01	367	2	0%
Dicamba	21%	0.27	2,619	702	2%
Dichloro O Anisic Acid	6%	0.14	739	101	0%
Diflufenzopyr	2%	0.05	264	13	0%
Dimethenamid	7%	0.94	896	839	3%
Fipronil	2%	0.13	221	28	0%
Flumetsulam	19%	0.04	2,394	106	0%
Glufosinate-Ammonium	5%	0.33	612	204	1%
Glyphosate	13%	0.90	1,668	1,495	5%
Imazapyr	3%	0.01	341	4	0%
Imazethapyr	3%	0.04	341	14	0%
Mesotrione	20%	0.12	2,556	296	1%
Nicosulfuron	19%	0.02	2,376	52	0%
Primisulfuron	2%	0.01	200	2	0%
Rimsulfuron	15%	0.01	1,912	22	0%
S-Metolachlor	24%	2.43	2,970	7,228	23%
Tebupirimphos	3%	0.14	367	50	0%
Tefluthrin	3%	0.12	324	38	0%

Soybean acres received pesticide applications from 21 different compounds (Table 20).

Table 20. Pesticide Use on Soybean Acres.					
Name Of Active Ingredient	Percent Of All Surveyed Corn Acres	Rate Applied Pounds per Acre Per Year	Total Acres Treated	Total Pounds Applied	Percent of Total AI Applied to Surveyed Corn Acres
2,4-D	10%	0.50	1,179	585	3%
Chlorimuron-Ethyl	1%	0.01	93	<1	0%
Chlorpyrifos	39%	0.50	4,729	2,365	13%
Clethodim	1%	0.08	83	6	0%
Cloransulam-Methyl	1%	0.02	83	1	0%
Esfenvalerate	3%	0.03	344	11	0%
Fenoxaprop-P-Ethyl	8%	0.02	956	23	0%
Fluazifop-P-Butyl	8%	0.09	956	82	0%
Flumetsulam	1%	0.05	143	7	0%
Fomesafen	14%	0.25	1,657	419	2%
Glyphosate	83%	1.27	10,216	12,989	74%
Imazamox	3%	0.04	401	16	0%
Imazethapyr	11%	0.05	1,343	61	0%
Lambda-Cyhalothrin	27%	0.02	3,276	77	0%
Metribuzin	1%	0.22	175	39	0%
Pendimethalin	0%	0.68	24	16	0%
Quizalofop P Ethyl	4%	0.03	435	12	0%
S-Metolachlor	1%	0.93	175	163	1%
Sulfentrazone	3%	0.19	360	68	0%
Thifensulfuron	10%	0.01	1,260	2	0%
Trifluralin	7%	0.75	882	662	4%

Table 21 lists all pesticide applications to crops other than field corn or soybeans.

Table 21. Pesticide Use on Other Crop Acres.			
Crop Type	Compound AI	Acres Treated	Pounds Applied
Sweet Corn	Atrazine	101	45
Sweet Corn	Dimethenamid	101	90
Peas	Trifluralin	304	152
Alfalfa	Chlorpyrifos	160	80
Oats	Chlorpyrifos	52	26

Pesticides were impregnated and applied on 4,789 acres of cropland. All impregnated pesticides were applied on corn except for 80 acres of peas. Over 9,600 pounds of active ingredients were applied through impregnation. Table 22 details the amount of active ingredient applied and acres treated. Thirty-seven percent of all corn acres received pesticides through impregnation on fertilizer.

Table 22. Pesticide Use and Acres Treated by Active Ingredient for Impregnated Pesticides.

Name Of Compound	Acres Treated	Total Pounds Applied
2,4-D	35	17
Acetochlor	2,242	4,144
Atrazine	1,567	1,170
Clopyralid	110	13
Dicamba	128	7
Dichloro O Anisic Acid	128	18
Dimethenamid	489	481
Flumetsulam	110	5
Mesotrione	277	33
S-Metolachlor	1,815	3,730
Trifluralin	80	40

Pesticides were most often applied post-emergence in regard to acres treated (Figure 22).

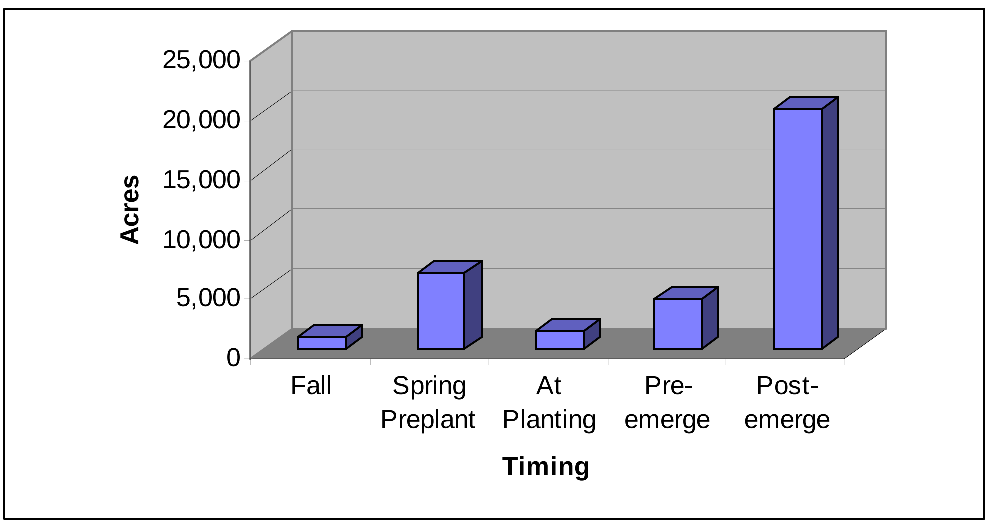


Figure 22. Pesticide applied by acres covered on all surveyed acres applied with pesticides.

Post-emergence dominated pesticide application timing for both corn (Figure 23) and soybeans (Figure 24).

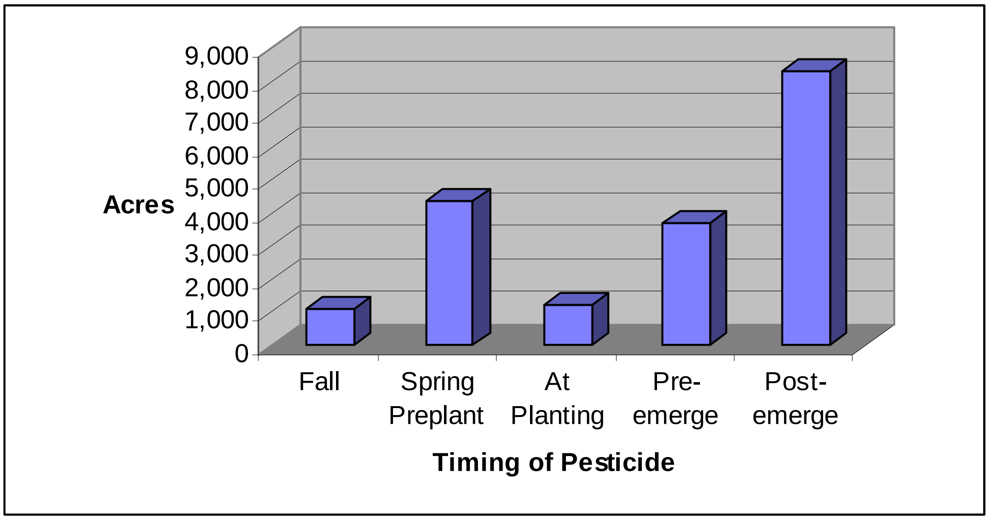


Figure 23. Pesticides applied to all surveyed corn acres by acres and timing.

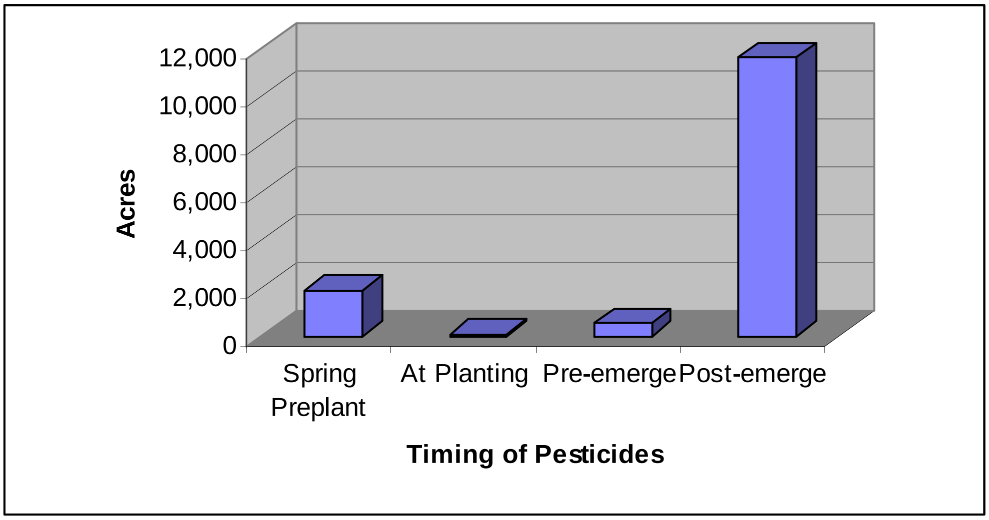


Figure 24. Timing of pesticides applied to all surveyed soybeans by acres and timing.

All pesticides were broadcast except for 1,000 acres of insecticide on surveyed corn acres.

Pesticide use on corn acres was dominated by Atrazine, Acetochlor and S-Metolachlor. Together they account for 84% of all pesticides applied to corn by weight. These are also the only products to be applied to more than 23% of all surveyed corn acres.

Atrazine was applied in various amounts by the surveyed farmers. Forty percent of the acres were applied with less than 0.6 pounds AI of Atrazine (Figure 25).

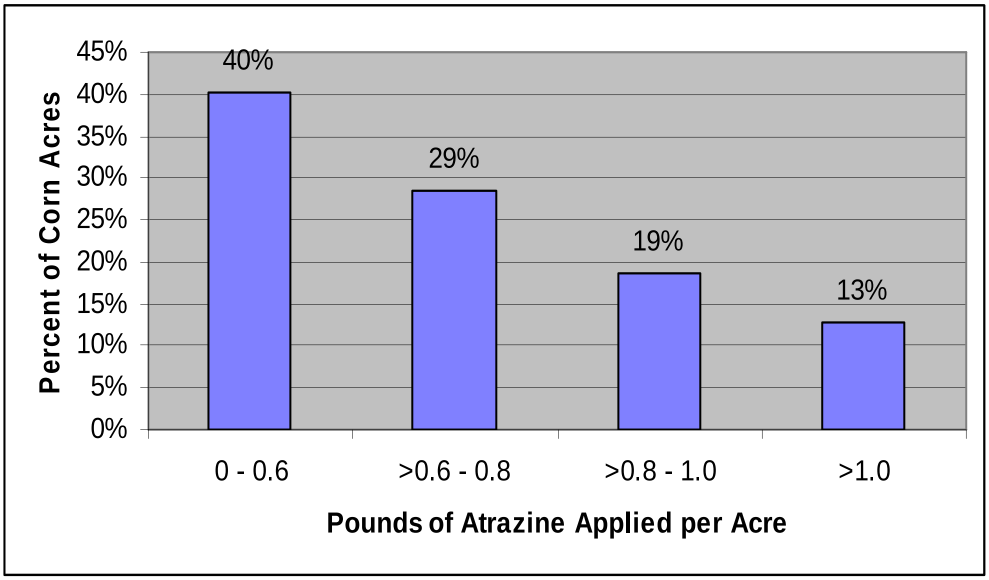


Figure 25. Percent of Atrazine applied to corn acres by rate.

The largest amount of Atrazine was applied post-emergence (Figure 26).

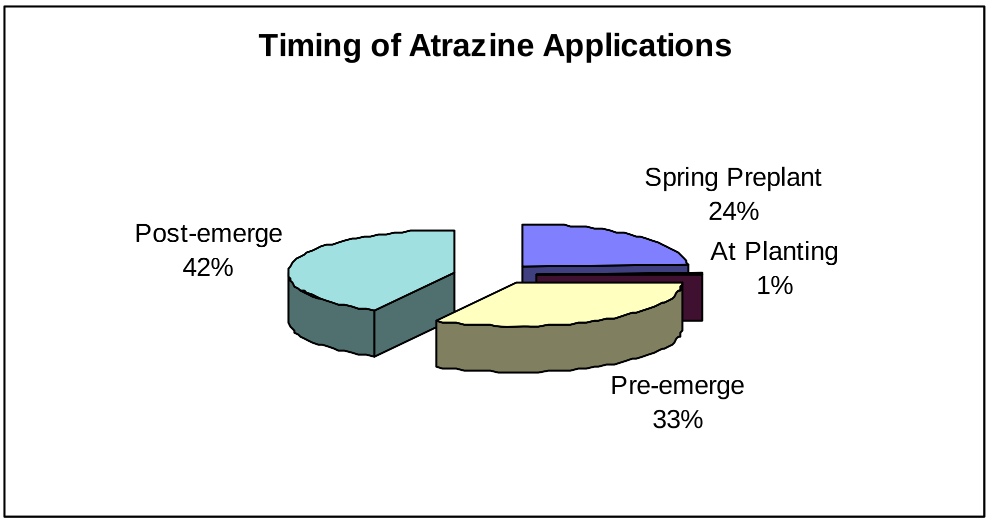


Figure 26. Percent of Atrazine applied to inventoried corn acres by timing and pounds applied.

Atrazine was the most used pesticide as a function of acres treated. Atrazine applications amounts per acre were generally below maximum recommended amounts according to the label. However, Atrazine is the most prevalent pesticide in streams in southeast Minnesota, and the South Branch of the Root River.

Best Management Practices for Atrazine, as developed by the MDA, states for Southeast Minnesota: Limit total Atrazine use per year to 0.8 lbs of active ingredient per area on all soils, except on medium and fine textured soil, where a total of 1 lb of active ingredient per year can be used for pre-emergence control. In the SBRR 87% of all acres treated with atrazine adhered to the BMP.

Acetochlor was applied in various amounts by the surveyed farmers. Fifty-three percent (53%) of the acres were applied with rates of Acetochlor between 1.5 and 2 pounds per acre (Figure 27).

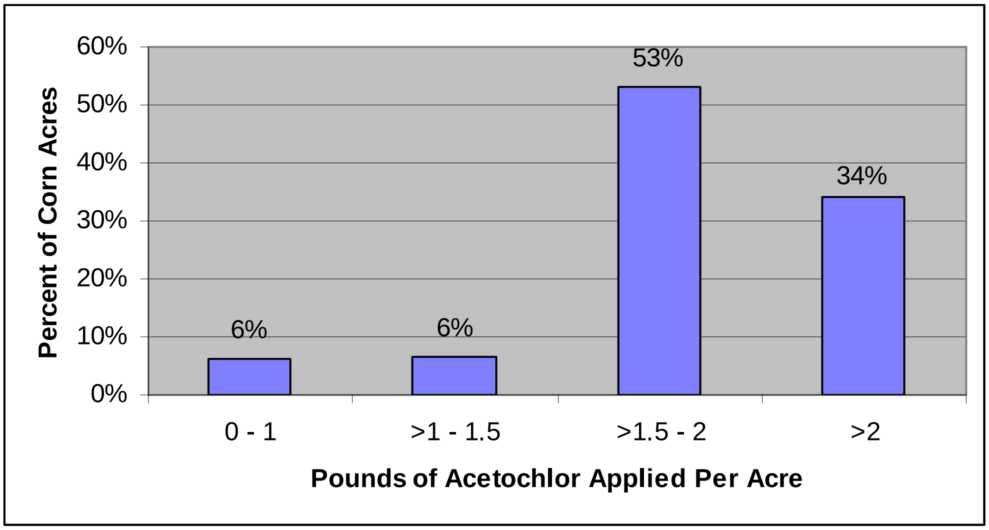


Figure 27. Percent of Acetochlor applied on surveyed corn acres by rate.

The largest amount of Acetochlor was applied as a spring pre-plant. (Figure 28).

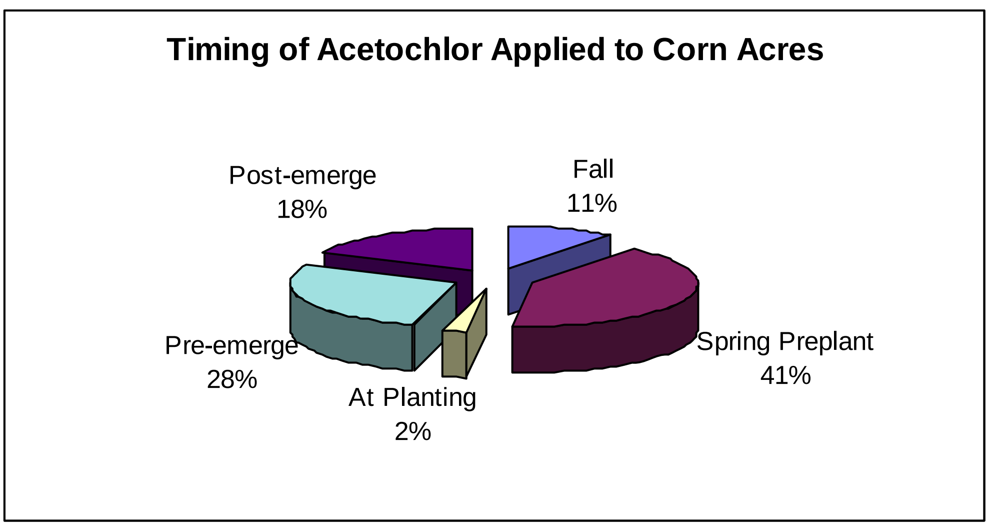


Figure 28. Percent of Acetochlor applied to surveyed corn acres by timing and pounds of AI applied.

S-Metolachlor was applied in various amounts by the surveyed farmers. Forty-seven (47%) of the acres were applied with rates of S-Metolachlor between 1.7 and 2 pounds per acre (Figure 29).

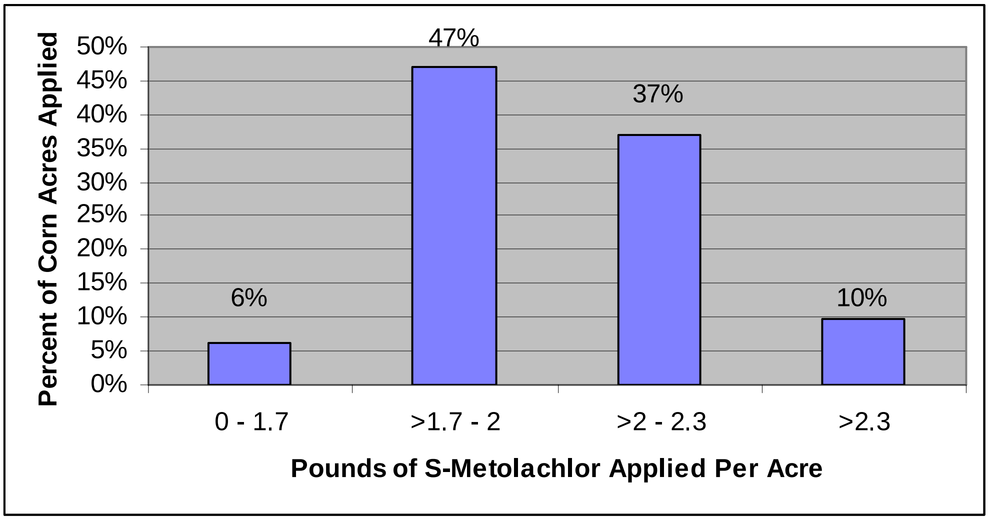


Figure 29. Percent of S-Metolachlor applied on surveyed corn acres by rate.

The largest amount of S-Metolachlor was applied as a spring pre-plant. (Figure 30).

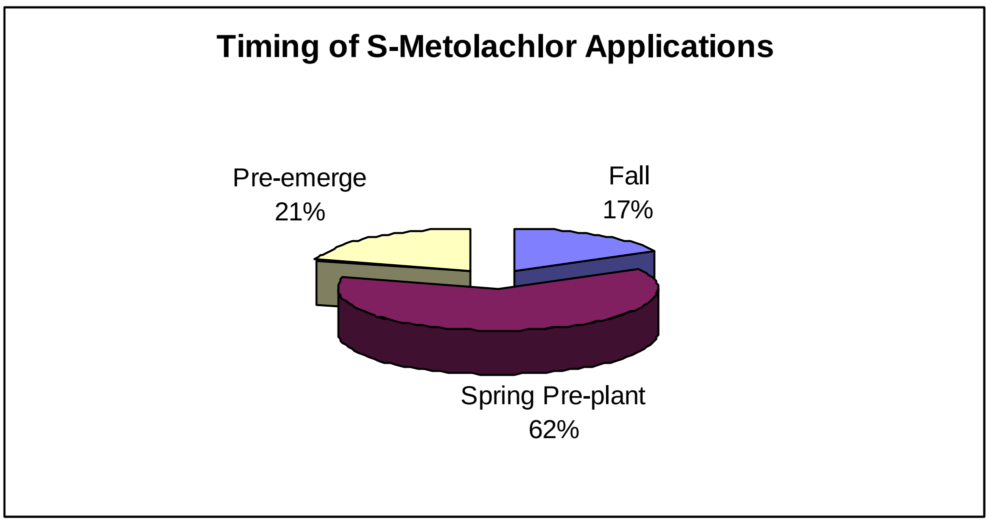


Figure 30. Percent of S-Metolachlor applied to surveyed corn acres by timing and pounds of AI applied.

Pesticide use on soybeans was dominated by Glyphosate which was applied on 83% of all soybean acres and accounted for 74% of all AI applied to surveyed soybean acres. Figure 31 details the rates of Glyphosate across all inventoried soybean acres. Ninety-five percent (95%) of all Glyphosate was applied as a post-emergence application.

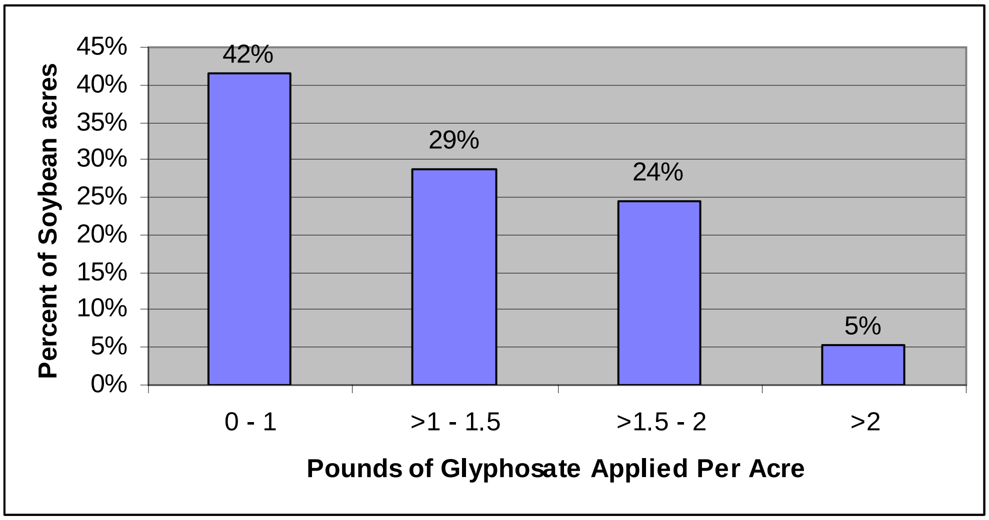


Figure 31. Percent of Glyphosate applied on inventoried soybean acres by rate of AI.

Conclusions and Summary of the Current Nutrient, Tillage and Pesticide Management Practices for the South Branch Root River.

The South Branch of the Root River is a 74,000 acre watershed that lies across Fillmore and Mower counties. Sixty-one farmers, farming 30,600 acres in the SBRR, were interviewed by the Minnesota Department of Agriculture using the Farm Nutrient Management Assessment Program (FANMAP) tool. Producers volunteered one to three 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, tillage and pesticides, and, to use this knowledge for future water quality educational programs.

Approximately 42% of the crop acres within the SBRR were inventoried. Field corn and soybeans were the dominant crops with 82% of all acres planted to these crops. Forty-two percent (42%) of the crop acres were planted with field corn and 97% of the 1,704,000 pounds of commercial N was applied to those field corn acres. Fifty-seven percent (57%) of all N applied was during spring pre-plant applications. Anhydrous ammonia (30%) and urea (36%) accounted for 66% of N applied to field corn. Fall applications of N are not recommended in Fillmore County and are allowed in Mower County if applications of N are delayed until soil temperature reaches a consistent 50°. Only 20% of the commercial N was applied as a fall application.

Field corn accounted for 91% of the commercial of the commercial P fertilizer applied to inventoried acres. Starter applications of commercial P accounted for 45% of the P applied, with fall and spring pre-plant applications accounting for the other 32% and 23% respectively.

Livestock raised in the SBRR was dominated by beef operations with 42% of the manure N produced. However, due to the lack of collecting beef manure from pasturing and over wintering on cropland, and also due to non-incorporation of beef manure, and hog manure being brought into the watershed, 71% of the first year available N was from hog manure. Manure was applied on 2,369 acres of corn and an additional 344 acres of other crops. Fall applications of manure accounted for 72% of the manure N applied.

Manure N accounted for 9% of all relative N contributions with legumes and commercial N accounting for 18% and 73%, respectively. Soybeans were the dominant source of legume N credits accounting for more than 93% of all legume N credits.

On average, inventoried farmers were over-applying N by 17 lb/A. on inventoried corn acres. Inventoried corn acres not applied with manure were over-applied by 15 lb/A and corn acres with manure were over-applied by 32 lb/A. Seventeen percent (17%) of the inventoried corn acres were at or below the UM recommendations for N. Farmers with yield goals for corn of 175 bushels per acres were over-applying by 33 lb/A. Farmers with lower yield goals were over-applying by 15 lb/A or less. Corn acres with high yield goals and manure were over-applying by 57 lb/A. Corn acres with hog manure were over-applied by 69 lb/A. Nutrient management plans by the NRCS do allow for an overage of 20% in regard to N when manure is applied, due to variability of the manure. Also corn acres in Mower County were over-applied by 29 lb/A and Fillmore County corn acres were over-applied by 14 lb/A. A corn soybean rotation also provided more over-application of N than corn following corn or corn following alfalfa.

In regard to phosphorus, 74% of the soil tests were in the high or very high range. Phosphorus applications account for approximately 2/3 of the P needed for crop removal. However, because a large percentage of the soil tests were in the high or very high range, there may be an opportunity for additional reductions on those fields.

The SBRR varies in landscape across the watershed. There were only 2 tile intakes located within fields in the SBRR. However, 14,000 acres were tile drained.

Tillage practices varied across the inventoried farms with 84% of the acres planted to corn receiving some type of reduced tillage such as chisel, field cultivator, soil saver, or disc ripper. In regard to soybeans, 52% of the acres received similar reduced tillage as corn, but 43% of the acres were no-till. Thirty-seven percent (37%) of all corn acres were applied with fertilizers impregnated with pesticides and could add an aggressive tillage pass. Manure nitrogen applied and injected in the fall could also create another potentially aggressive tillage pass.

Pesticide use was prevalent in the SBRR, as 81% of all crop acres were treated with herbicides or insecticides. Pesticide use consisted of 58 different formulas or products. There were 40 separate active ingredients used in these pesticide applications, totaling 49,000 pounds of active ingredients. Field corn and soybeans accounted for 63% and 36% of all AI applied, respectively. Post-emergence applications dominated both corn and soybean acres.

Atrazine, Acetochlor, and S-Metolachlor were the most used pesticides on corn. Glyphosate was the dominate pesticide used on soybeans.

Inventoried farmers in the SBRR appear to represent a broad range of farming practices with many different practices applied across the watershed. It also appears that tillage, pesticides and nutrients are closely tied together in this watershed. Therefore, any changes in one area may affect changes in the other two, thus some educational efforts would need to take into consideration the current "package" of practices that farmers are currently using.

Some very positive results were discovered through this study. There is strong evidence that producers are voluntarily adopting the educational materials and recommended N management strategies developed by the UM for the SBRR, especially in regard to residue management. However, overall reductions in N can still be achieved with little chance of economic loss in the long term. 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 UM recommendations for the area.