DEPARTMENT OF AGRICULTURE

Fertilizer Nitrogen Sales in Minnesota and Fluctuations Over Time

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Summary

Many factors affect the use of nitrogen for Minnesota crops. Some of the main factors are:

- Corn acres harvested
- Increases in corn yields per acre/ total bushels of corn produced
- Price of corn
- University of Minnesota (UMN) rate guidance
- Price of fertilizer
- Loss of nitrogen in-season

- Corn acres account for the greatest use of nitrogen fertilizer in Minnesota because of the high proportion of cropland used for corn production compared to other crops, and the high requirement of nitrogen to produce good corn yields.
    - Increase in corn production for the last 20 years could be a partial result of the increase in corn for ethanol (which accounts for 30-40% of corn grown in Minnesota).

- Corn yields in Minnesota have been increasing. From 1963 to 2023 there was a 20 bushel increase every 10 years on average or two bushels per year
    - The years between 1993 to 2003 saw an increase of 30 bushels.

- Price of corn has increased over time, so has the price of farmland. On rented acres, land rent is often the largest cost of production, followed by the cost of fertilizer.

- University of Minnesota (UMN) nitrogen rate guidance for corn has increased overtime. The MRTN was held constant from 2006 to 2016 for non-irrigated corn. Beginning in 2015 several increases in the MRTN were made for several crop rotations. Most dryland corn MRTN guidelines ranged between a 25% increase and a 29% increase from 2006 to 2023.
    - 2006 - 2015 NA
    - 2016 - 2018 increase for corn following corn: 10%
    - 2019 - 2022 increase for corn following corn: 6%
    - 2023 - 2024 increase for corn following corn: 6%
    - 2025 update - increase for corn following corn: 5%

- Tons of nitrogen recommended from UMN guidelines for nitrogen applied to corn acres in Minnesota has increased 41% from approximately 430,000 tons in 2010 to 620,000 tons in 2022.

- Nitrogen recommended for harvested corn acres in Minnesota has increased while the harvested corn acres have remained relatively stable.

Background

Minnesota collects agricultural fertilizer sales for each crop year. The crop year begins on July 1 and ends on June 30. The agricultural fertilizer sales provided in this report are in total pounds or short tons of product sold, unless otherwise noted. The nitrogen sales in this report are reported as the actual nitrogen within agricultural product sales[1].

Minnesota fertilizer dealers began reporting fertilizer sales in 2010. Prior to 2010, sales were reported by the manufacturer or distributor. This change in reporting reduced the large annual swings in reported sales in the years preceding 2010[2]. Each dealer must provide the actual amount of agricultural fertilizer sales to Minnesota customers.

This report will detail nitrogen fertilizer sales over time and various aspects of corn grown in Minnesota such as acres of corn, yield of corn, price of corn, previous crop grown before corn, University of Minnesota guidelines for corn, and price of nitrogen fertilizer.

Minnesota nitrogen sales have had an upward trend since the licensed agricultural dealers began reporting in 2010. Nitrogen sales on an annual basis does NOT represent the actual amount of nitrogen that is used for that specific year. Fluctuations can be from the weather that prevents planting or applications of nitrogen, as well as from farmers purchasing nitrogen in one crop year and applied another crop year.

In 2019 farmers in Minnesota applied an average of 153 pounds of N across all fertilized corn acres without manure and applied an average of 106 pounds of N across all acres applied with manure. This would have accounted for 449,482 tons of nitrogen for that specific crop year[3].

Minnesota fertilizer sales and corresponding nitrogen sales have been trending up since 2010. In 2023 Minnesota dealers reported more actual nitrogen sold than in any previous year. Minnesota yields have also been trending up since 2010 as well as the price of nitrogen and fertilizer.

[1] Example: 100 tons of urea (the product) is reported as 100 tons of agricultural fertilizer sales and is reported as 46 tons of actual nitrogen (urea has 46 pounds of actual nitrogen for each 100 pounds of product).

[2] Manufactures and distributors did not have information as to where the fertilizers products were being sold. Minnesota dealers often had out of state sales, and out of state dealers often had Minnesota sales. Manufacturers and distributors did not know how much fertilizer was actually sold each year and how much was in inventory. Dealers were often prudent in purchasing fertilizer for inventory when prices were to rise. Dealers in 2010 and forward only report actual sales to farmers each year.

[3] Commercial Fertilize Usage and Manure Management Practices Associated with Minnesota's 2019 Corn and Soybean Crops.

Nitrogen Fertilizer Sales Data and Related Minnesota Data

Figure 1 details the nitrogen sales from 2010 to 2023 as reported by fertilizer dealers.

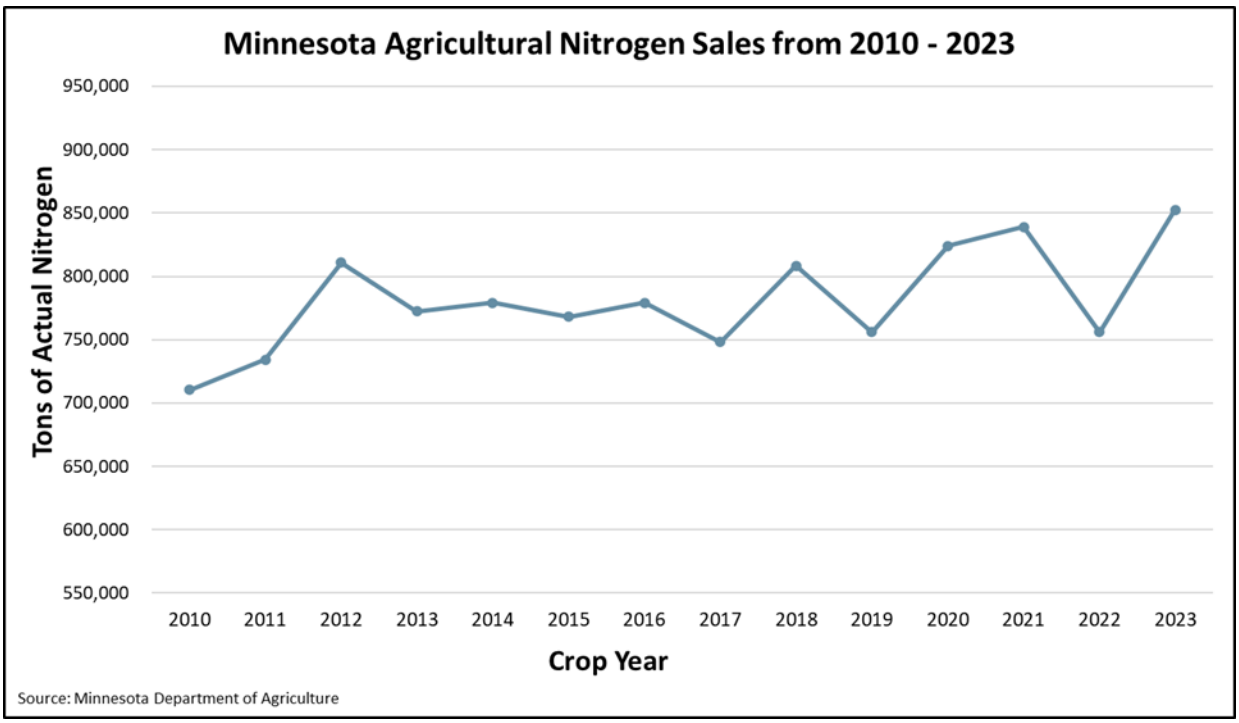

Figure 1. Tons of actual nitrogen reported sold in Minnesota by crop year from 2010 to 2023

Figure 2 details the Minnesota agricultural fertilizer sales for 2010 to 2023 as reported by the fertilizer dealers. Minnesota fertilizer sales reported by Minnesota dealers were highest in 2021.

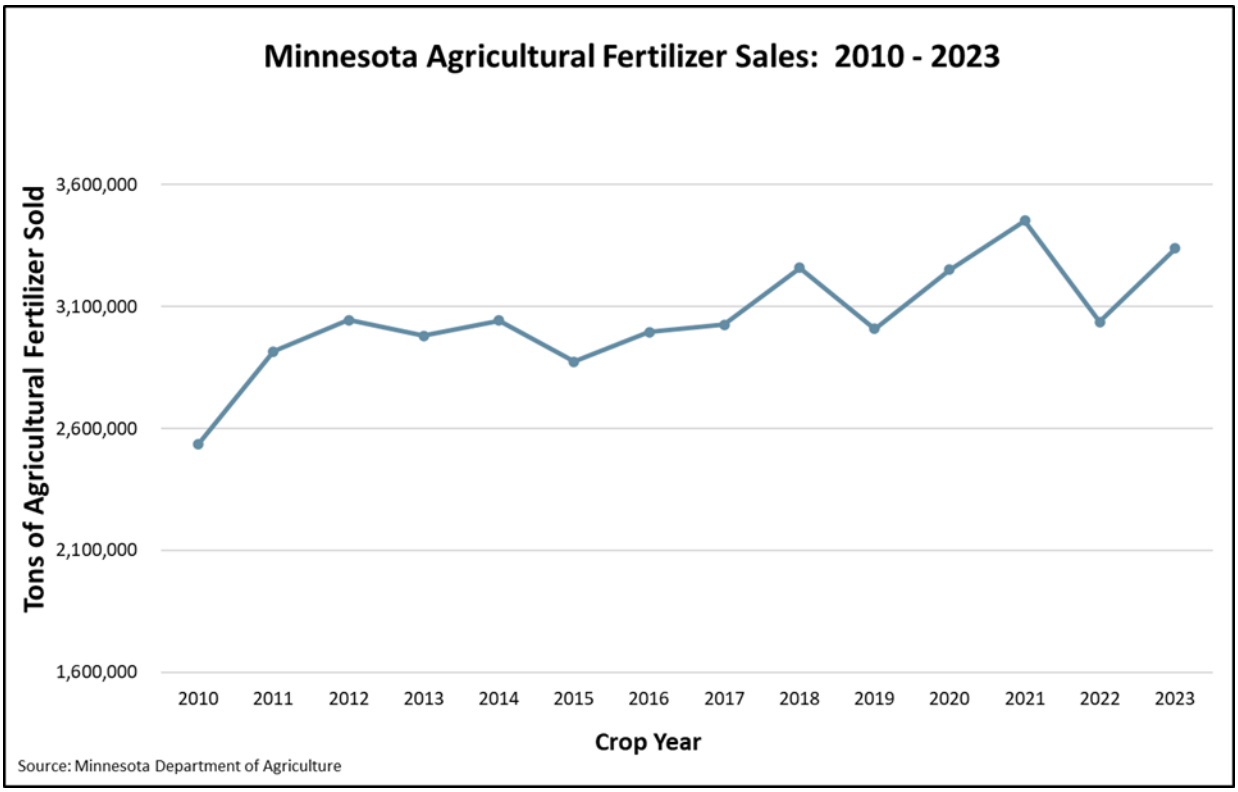

Figure 2. Tons of agricultural fertilizer sold in Minnesota by year from 2010 to 2023

Total actual nitrogen represented between 25% and 28% of agricultural fertilizer sales each year from 2010 through 2023. Figure 3 details the agricultural fertilizer sales and the actual nitrogen within those sales by year from 2010 to 2023.

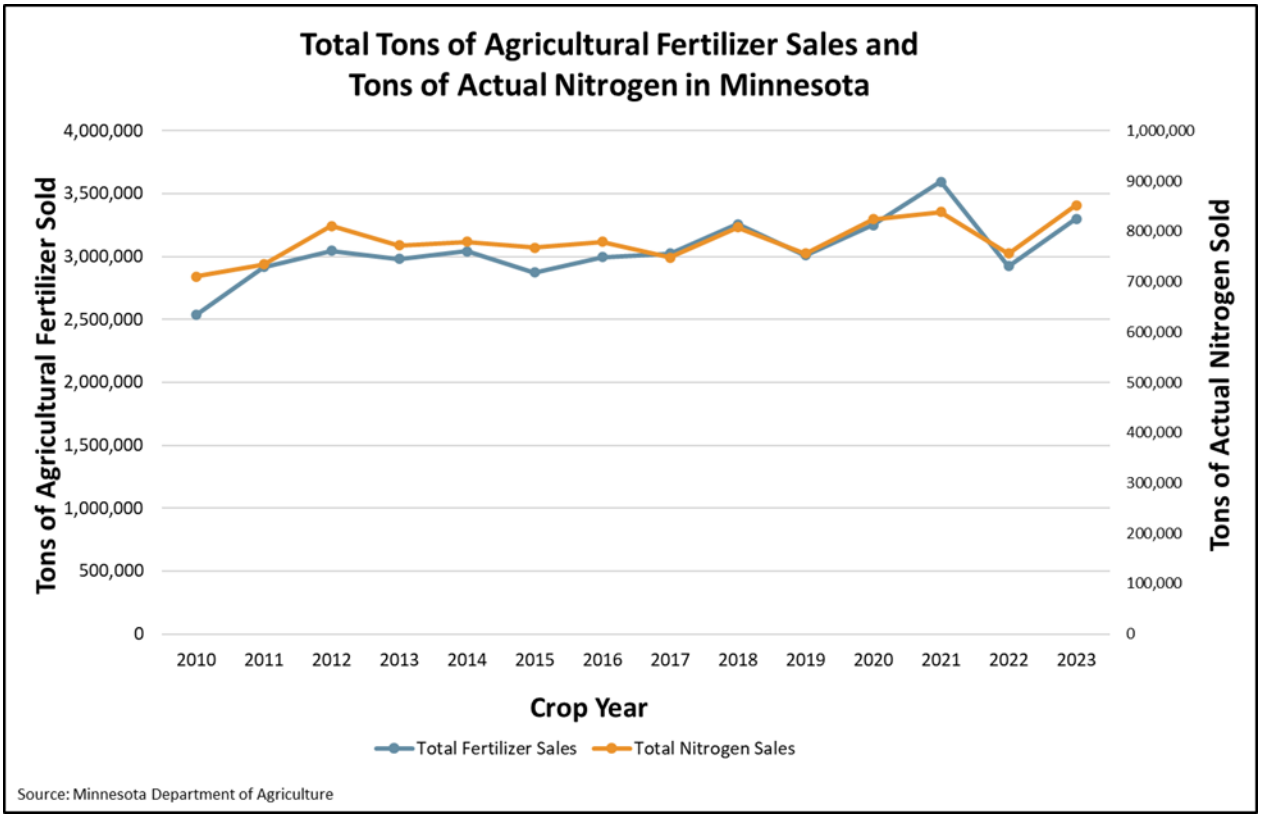

Figure 3. Tons of agricultural fertilizer sales reported sold in Minnesota by year from 2010 to 2023 and corresponding actual nitrogen within those sales.

Corn yields continue to increase over time in Minnesota. Figure 4 details the average annual harvested corn yields for grain statewide in Minnesota by year from 2010 to 2023. Corn acres in this report consist of only harvested corn acres for grain and do not include unharvested grain corn acres, silage acres, or sweet corn acres.

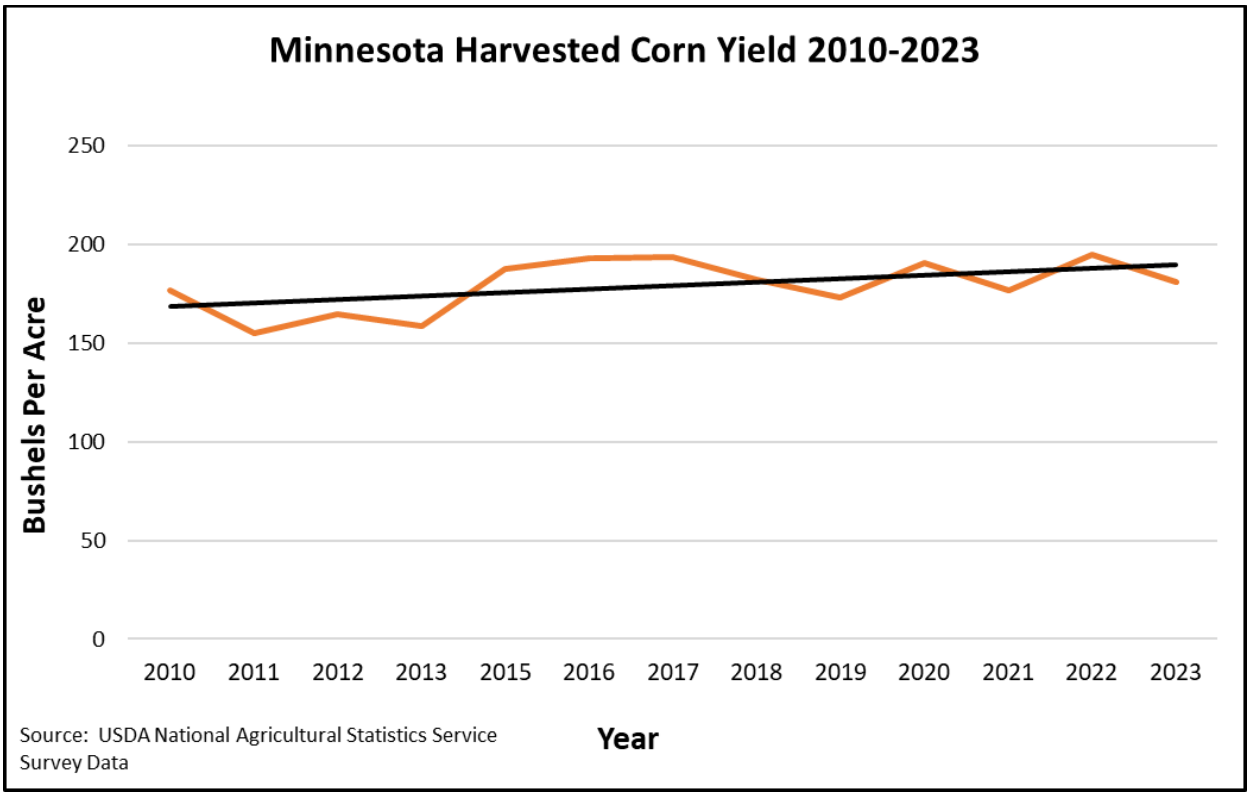

Figure 4. Average annual statewide corn yields harvested for grain by year from 2010 to 2023

Corn yields in Minnesota have been increasing over the past 100 years. Corn yields had little if any increases from 1908 until 1933, and from 1934 to 1963, yields increased approximately 20 bushels per acre over the 30-year period. However, beginning in the period from 1963 to 2023 there was a 20 bushel increase every 10 years on average or two bushels per year as shown in Figure 5.

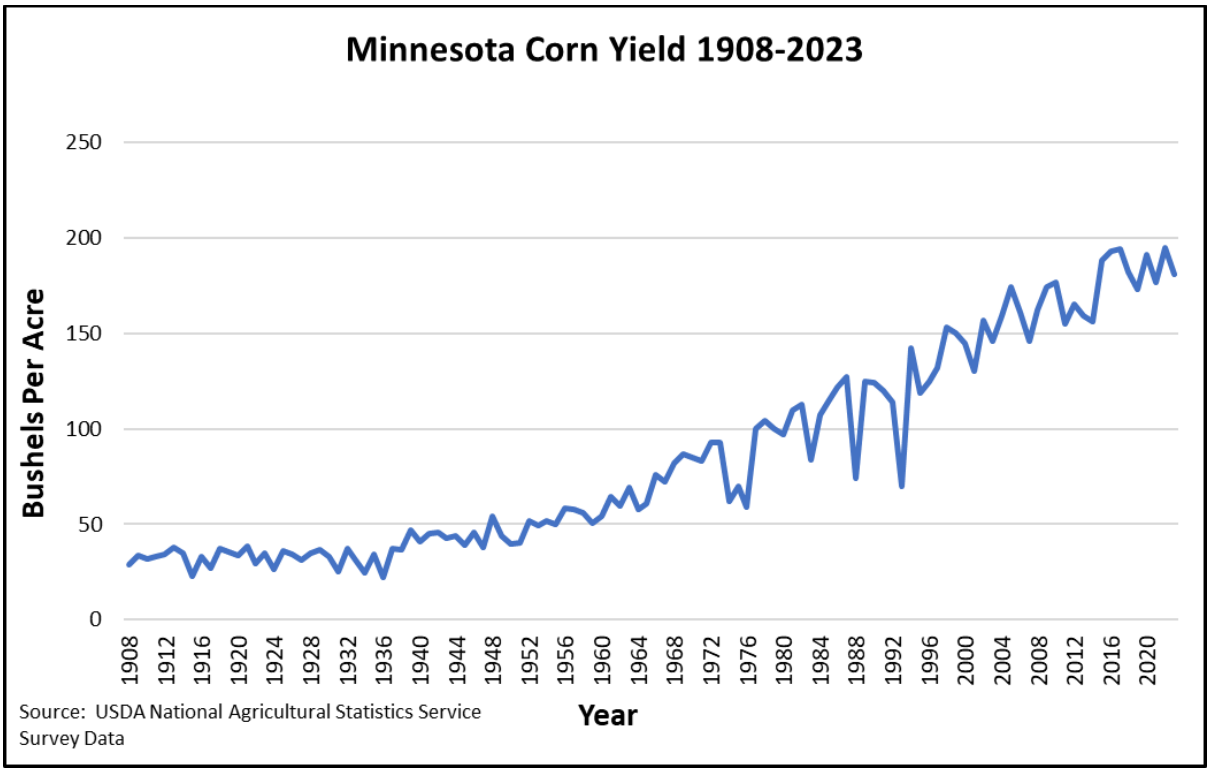

Figure 5. Average annual Minnesota corn yields by year from 1908 to 2023

Figure 6 details the average decadal corn yields over the past 100 years. Some 10-year periods only saw a 10-bushel increase, such as in the period between 1973 and 1983. Other 10-year periods, from 1993 to 2003, saw an increase of 30 bushels.

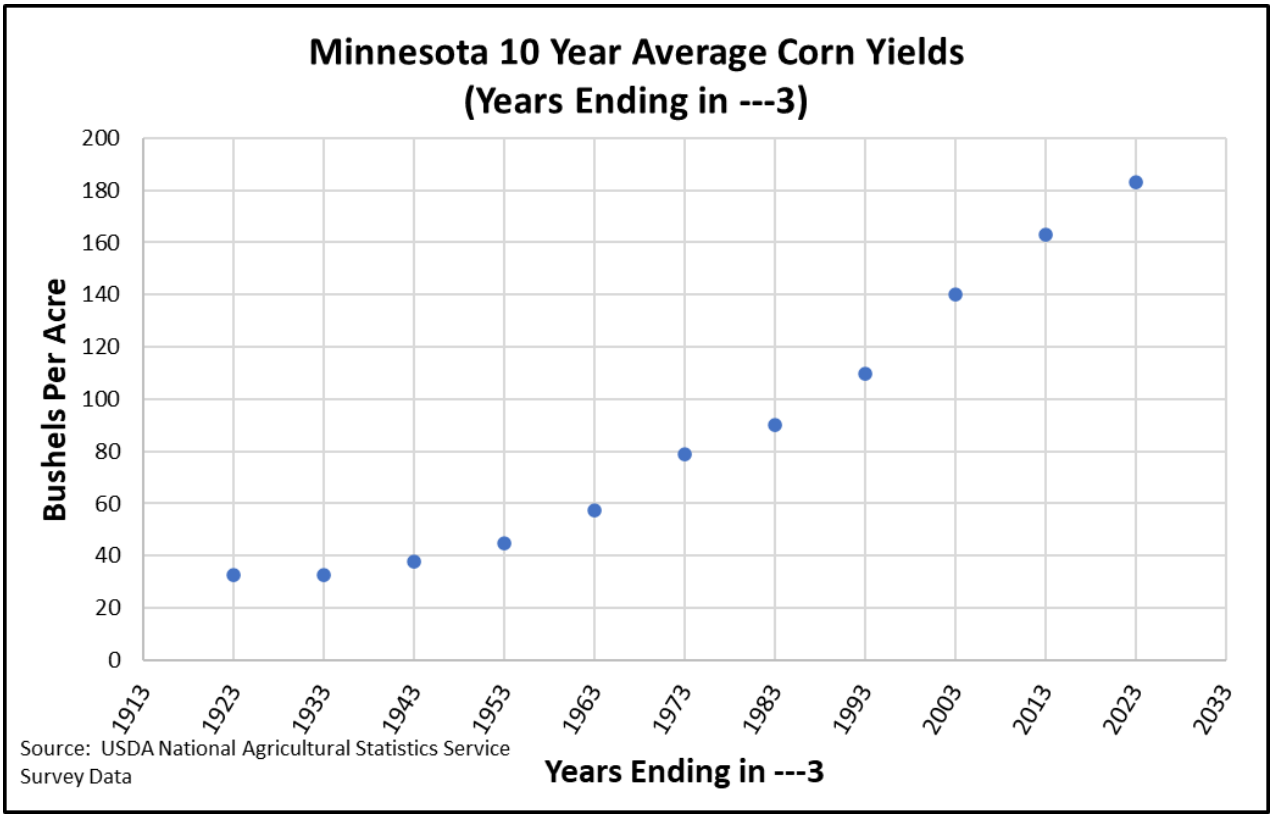

Figure 6. Minnesota average decade corn yields from 1913 to 2023

Corn yield generally increased by an average of 20 bushels per decade over the last 50 years, with the exception of a 10 bushel increase in the 1973-1983 period and an approximately 30 bushel increase in the 1993 to 2003 period.

From 1993 to 2023, each 10-year period has had average yield increases of between 20 and 30 bushels per acre[4]. Years of extreme yield drops[5] have not happened in the past 30 years. Figure 7 details the increase in corn yields by decade compared to the previous decade over the past 120 years. Since 1973 it appears that there is a 2 bushel per year increase, or a 20 bushel per decade increase.

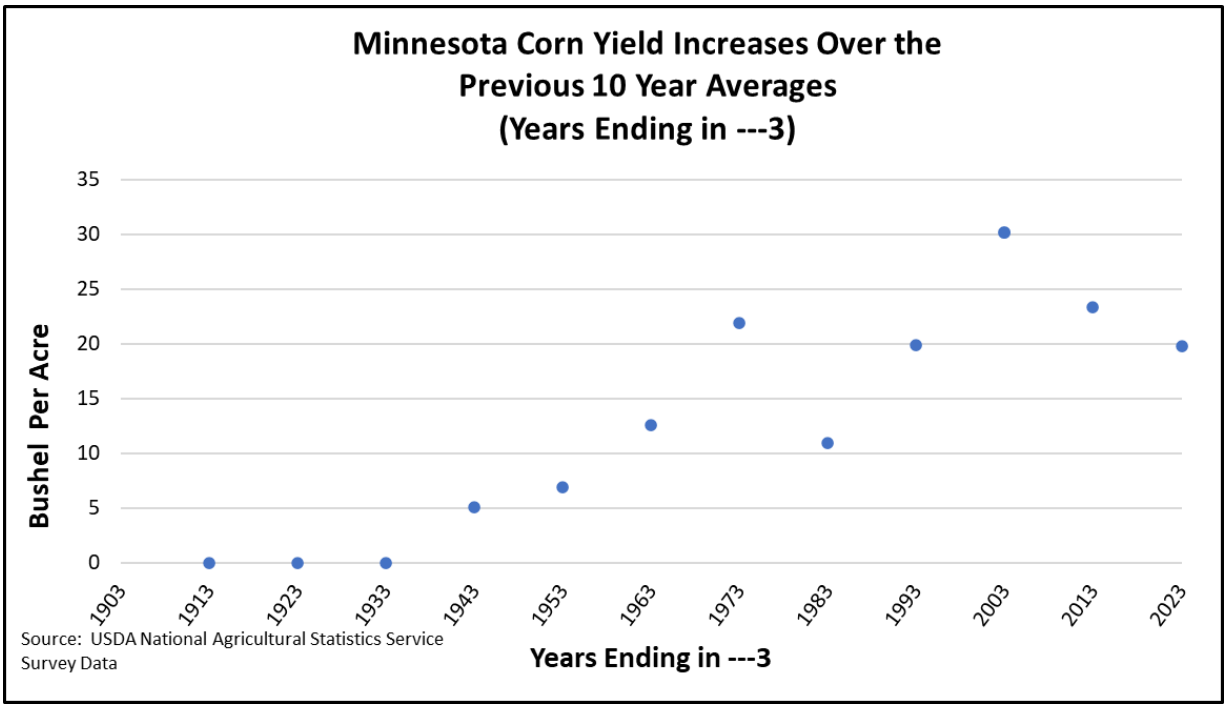

Figure 7. Minnesota's average decade corn yield increases by compared to the previous decade period from 1903 to 2023

[4] Ten-year averages were used to define yield increase per decade. Each yearly yield for the 10-year period was totaled and then divided by 10 to represent a 10-year average.

[5] In 1988 widespread drought and in 1993 widespread excess rain across the state led to yield reductions that caused yields to fall to 74 bushels per acre and 70 bushels per acre, respectively. These were both 50-bushel reductions from the previous years and affected the 10-year averages for the period of 1983-1993. The severe drought of the 1970's also drastically reduced yields for the 10-year averages for the period of 1973-1983. The largest yearly reduction was only 23 bushels per acre for the period of 1993 to 2023.

The price of corn per bushel has also increased over time. Figure 8 details the price of corn from 1908 to 2023.

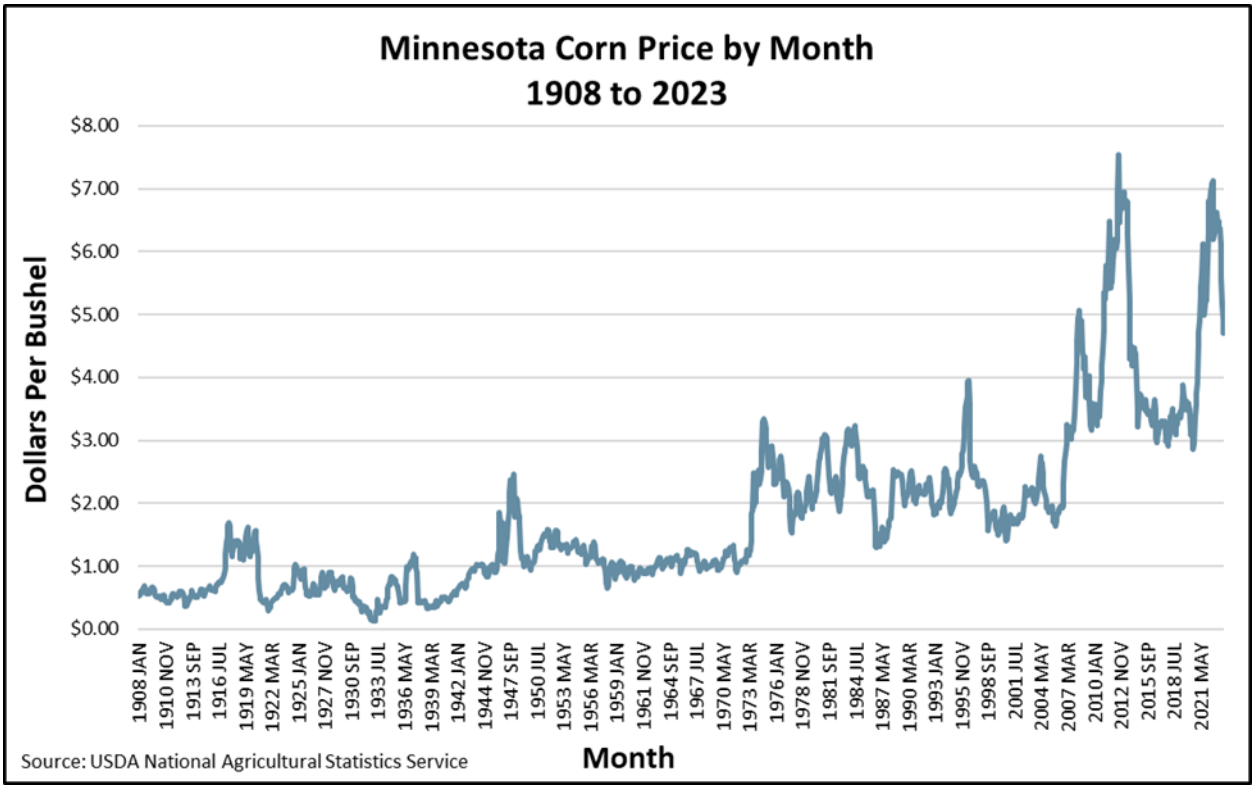

Figure 8. Minnesota monthly corn prices 1908 to 2023

Figure 9 details the increases in corn prices by 10-year periods[6]. There are four distinct periods where the price of corn remained relatively consistent. Corn prices ranged from $0.50 to $1.00 in the period of 1913 to 1943. Corn prices ranged from $1.00 to $1.50 in the period of 1943 to 1973. Corn prices ranged from $2.00 to $2.50 in the period of 1973 to 2003, and corn prices averaged approximately $4.00 per bushel from 2003 to 2023.

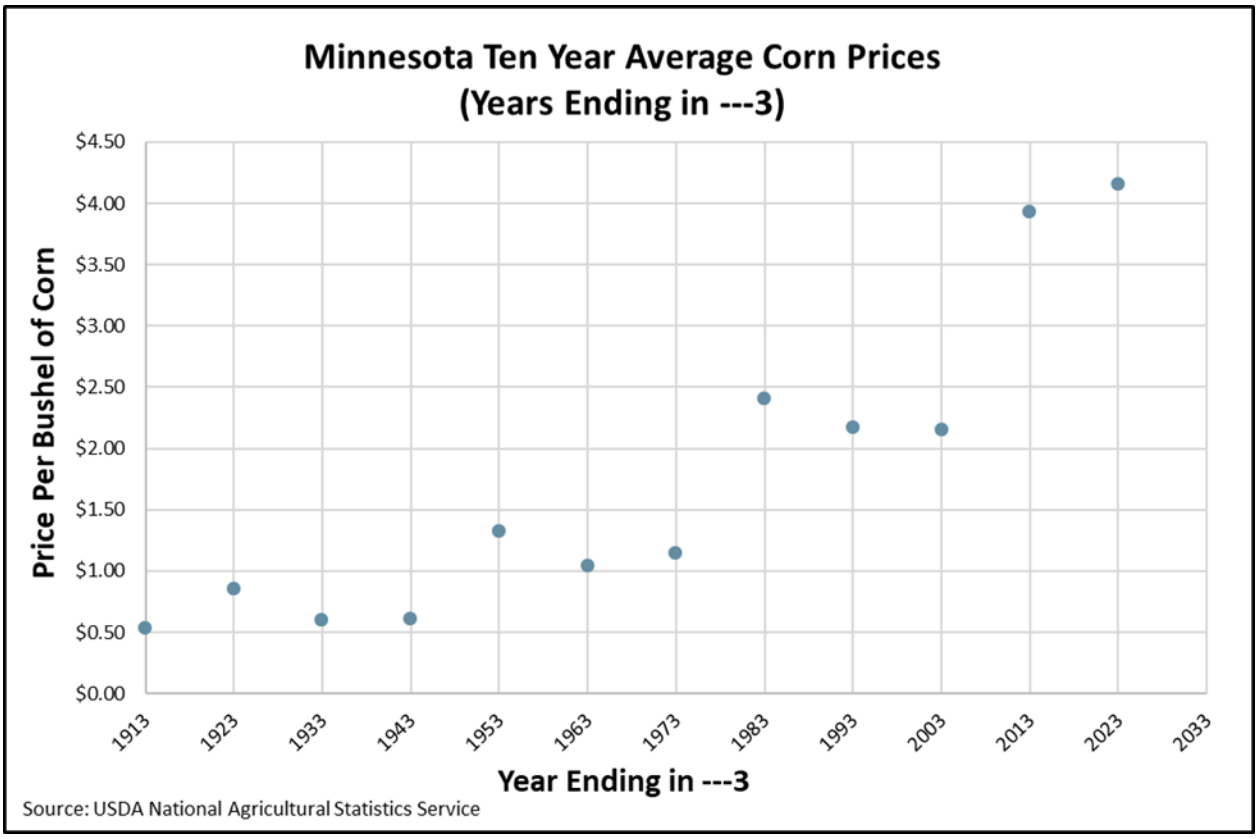

Figure 9. Minnesota corn prices by 10-year periods from 1913 to 2023

[6] Ten-year averages were used to define prices per 10 year period. Each yearly average price reported by the USDA National Agricultural Statistics Service for the 10-year period was totaled and then divided by 10 to represent a 10 year average.

Figure 10 details the use of corn in the United States[7]. In 2021, an estimated 454.1 million bushels of corn went into ethanol production in Minnesota, representing 31 percent of the 1.5 billion bushels harvested in the state that year. The following graph is provided by the USDA National Agricultural Statistics Service. It may be that the increase in corn prices for the last 20 years could be a partial result of the increase in corn for ethanol[8].

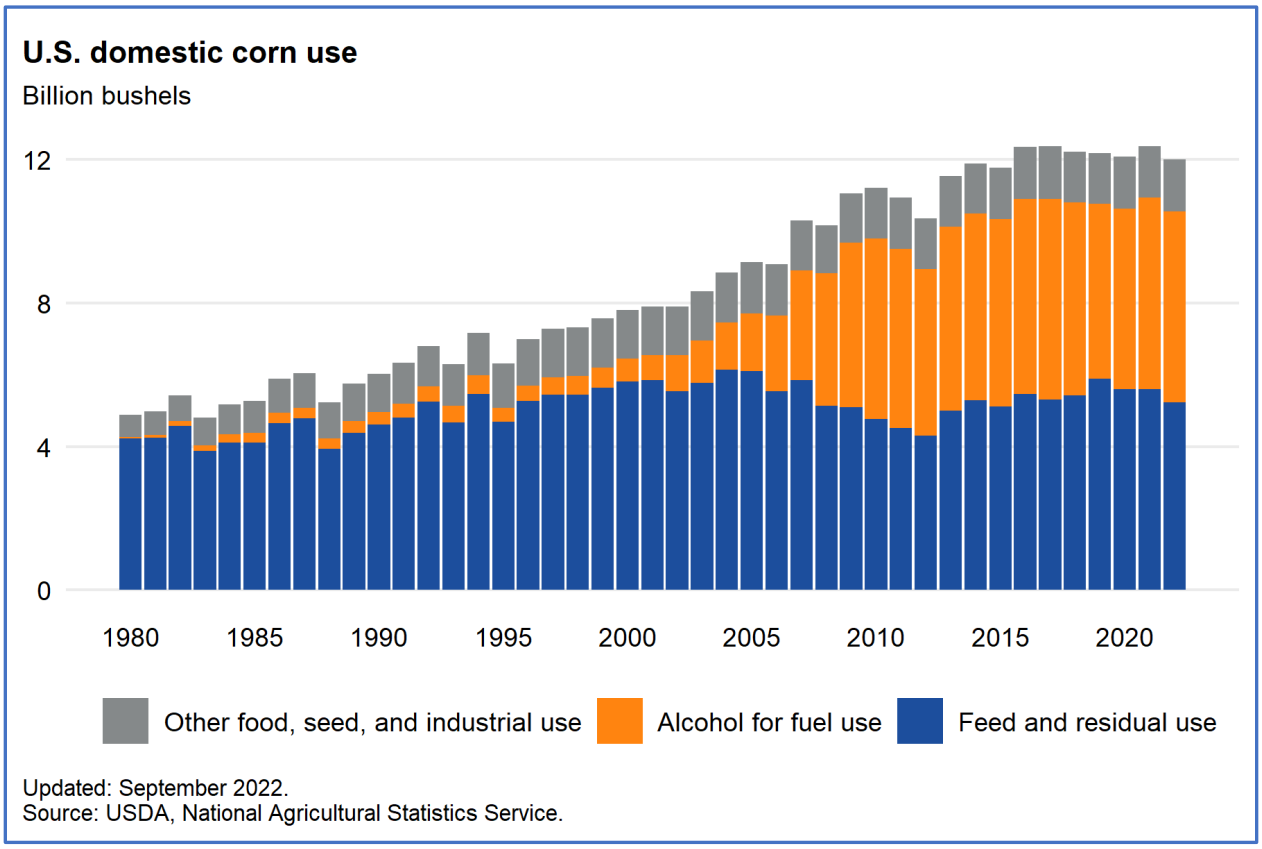

Figure 10. United States domestic corn use from 1980 to 2022

[7] The chart is provided by the USDA economic Research Service a division of the National Agricultural Statistic Service. It was originally provided at the following site:
U.S. domestic corn use | Economic Research Service

[8] USDA has reported that Biofuels (alcohol) was a major contributor for the price increase in corn (ARS Amberwaves) as well several research papers, Roberts and Schlenker (2013), Hausman, Auffhammer, and Berck (2012)

Sales of actual nitrogen compared to variables that may cause increases or decreases in actual nitrogen sales.

Many factors could affect the use of nitrogen for Minnesota crops. Corn acres account for the greatest use of nitrogen fertilizer in Minnesota because of the high proportion of cropland used for corn production compared to other crops, and the high requirement of nitrogen to produce high corn yields. This section will compare the sales of actual nitrogen with several variables such as corn acres, corn yield, corn price, and nitrogen price.

Figure 11 shows the increase in corn yields and the increase in actual nitrogen from fertilizer sold in Minnesota.

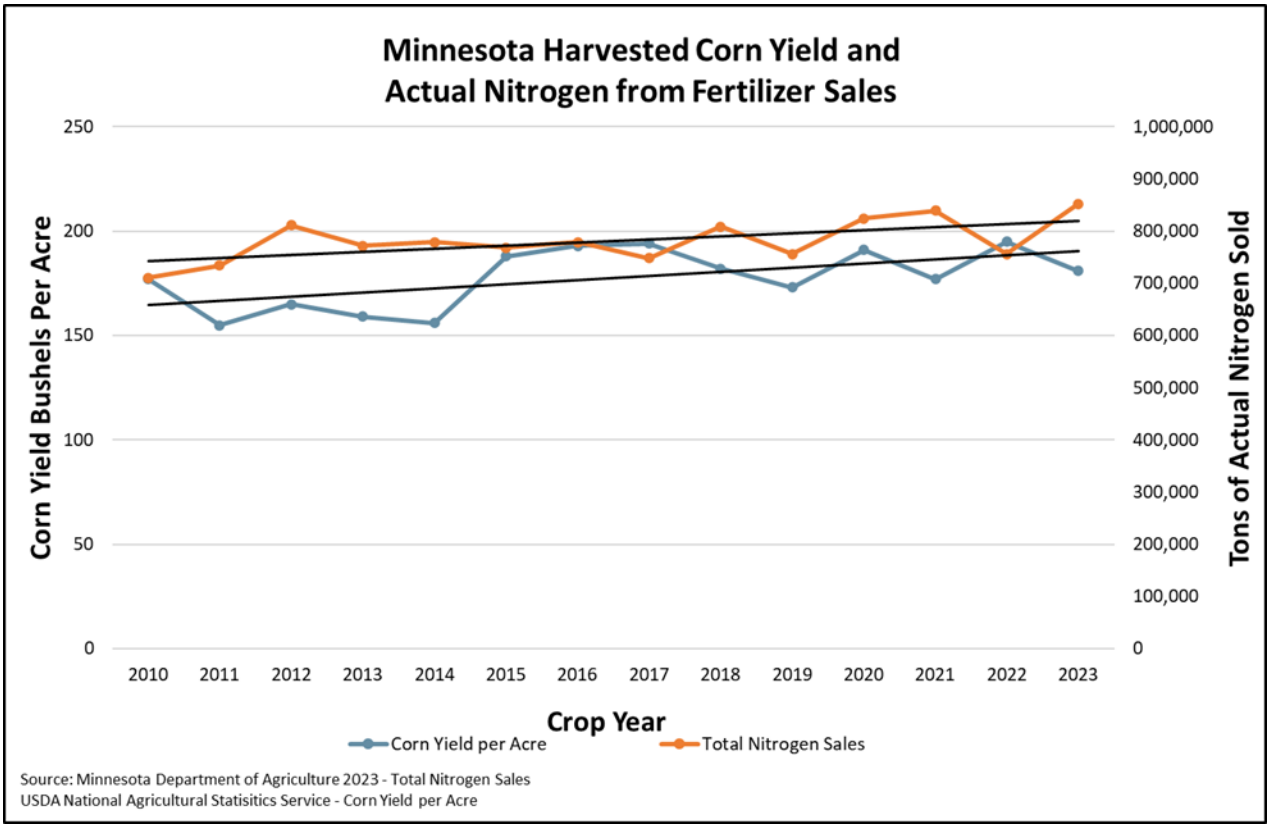

Figure 11. Minnesota corn yields in bushels/acre and total actual nitrogen sales from 2010 to 2023

Acres of corn harvested in Minnesota has averaged approximately 8,000,000 acres from 2010 to 2023. All years during that period have been within 500,000 acres of 8,000,000 except for 2012 as shown in Figure 12.

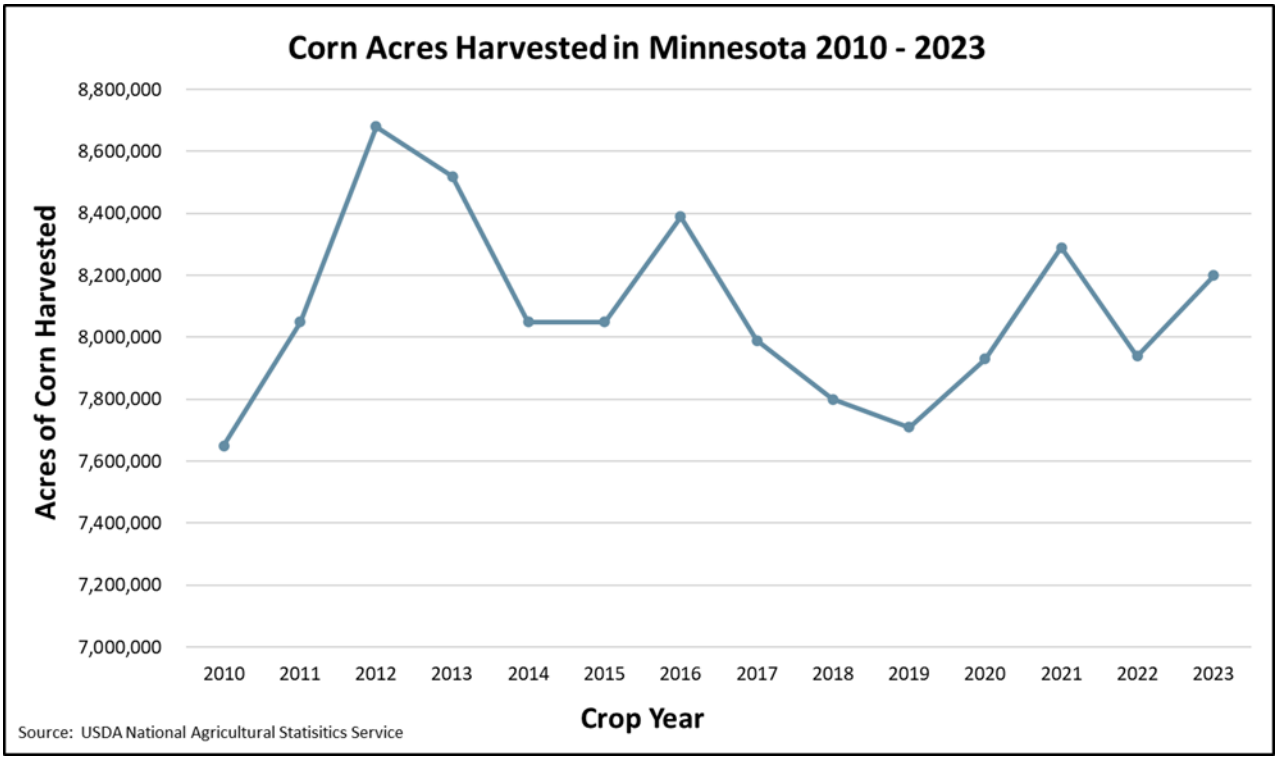

Figure 12. Minnesota harvested corn acres from 2010 to 2023

Figure 13 details the total corn acres harvested in Minnesota and total actual nitrogen sales.

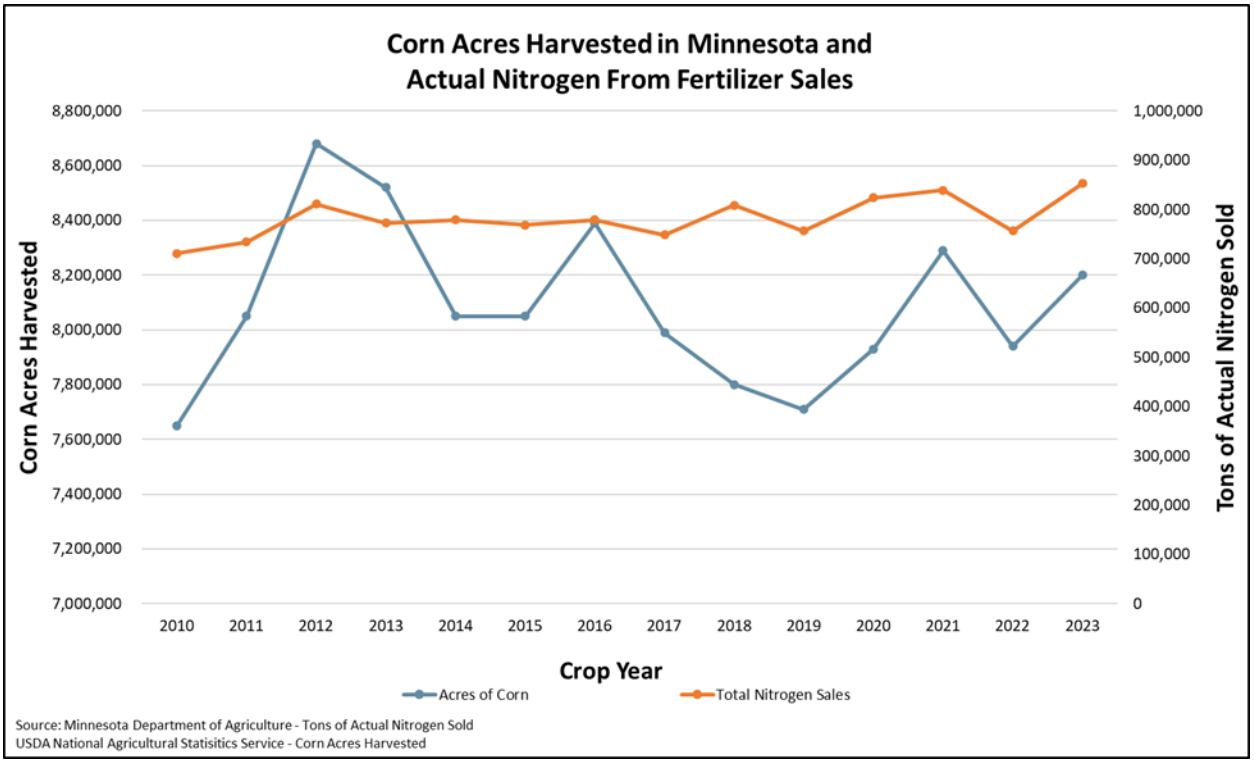

Figure 13. Minnesota harvested corn acres and total actual nitrogen sales from 2010 to 2023

Nitrogen prices were at an all-time high in 2022 as reported by DTN[9]. Figure 14 details the average price of actual nitrogen by year. Information was from DTN and consists of the price of urea[10] over time as measured each year in February. The data is for the United States; however Minnesota's average price is generally within a 10 percent of the national average price.

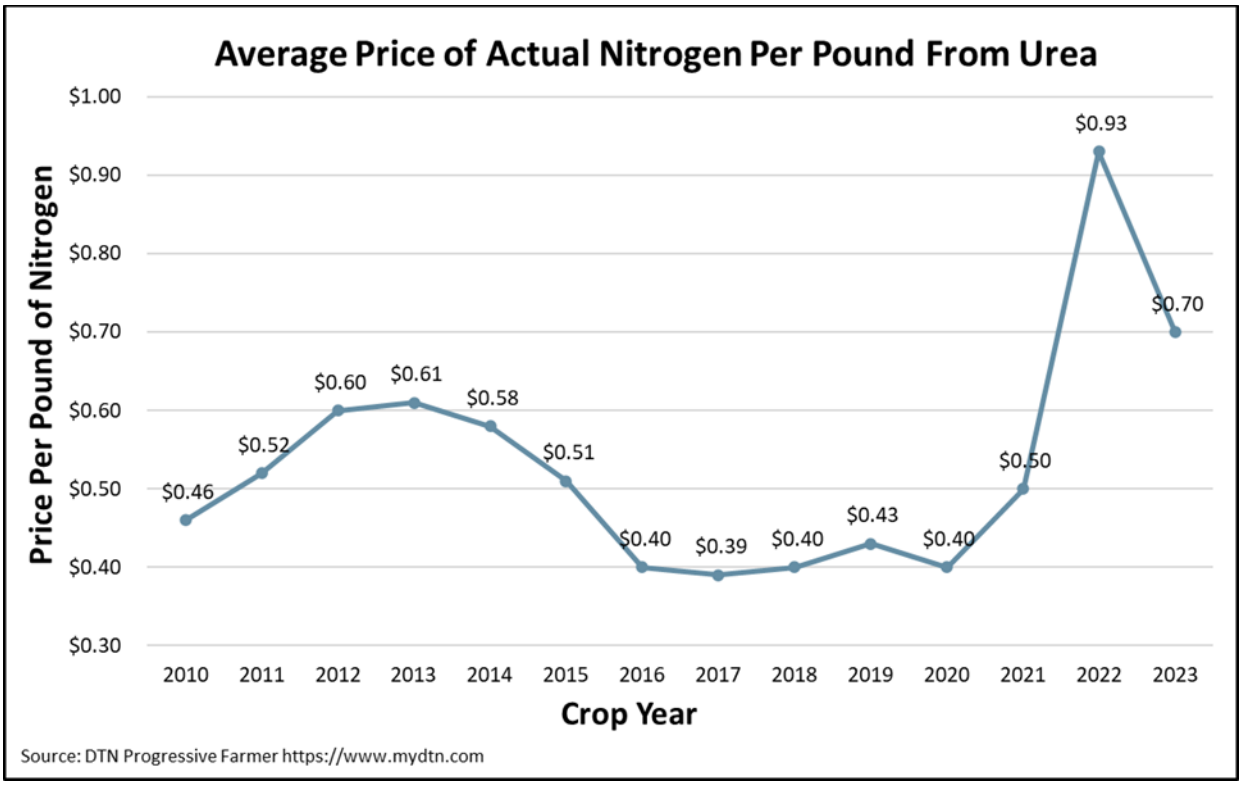

Figure 14. Minnesota price of actual nitrogen per pound from urea for the period of 2010 to 2023

[9] DTN is a site that collects weekly reports of fertilizer prices from most of the largest agricultural states by having dealers report current fertilizer prices.

[10] Urea is the source of most actual nitrogen sold in Minnesota.

Figure 15 details the price of nitrogen and the total nitrogen sales in Minnesota.

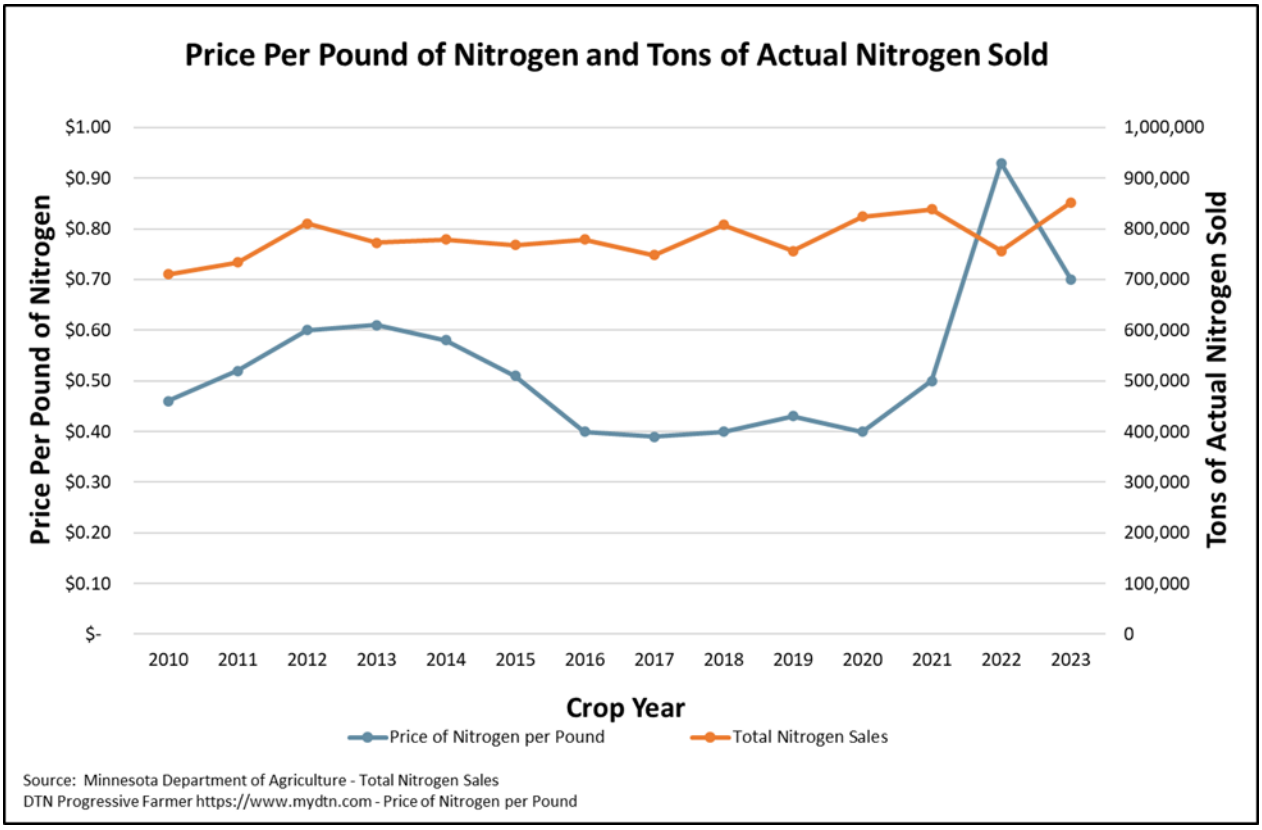

Figure 15. Minnesota price of actual nitrogen per pound and total tons of actual nitrogen sold from 2010 to 2023

Figure 16 details the annual price of corn per bushel Minnesota farmers received as reported by the USDA for the period of 2010 through 2023.

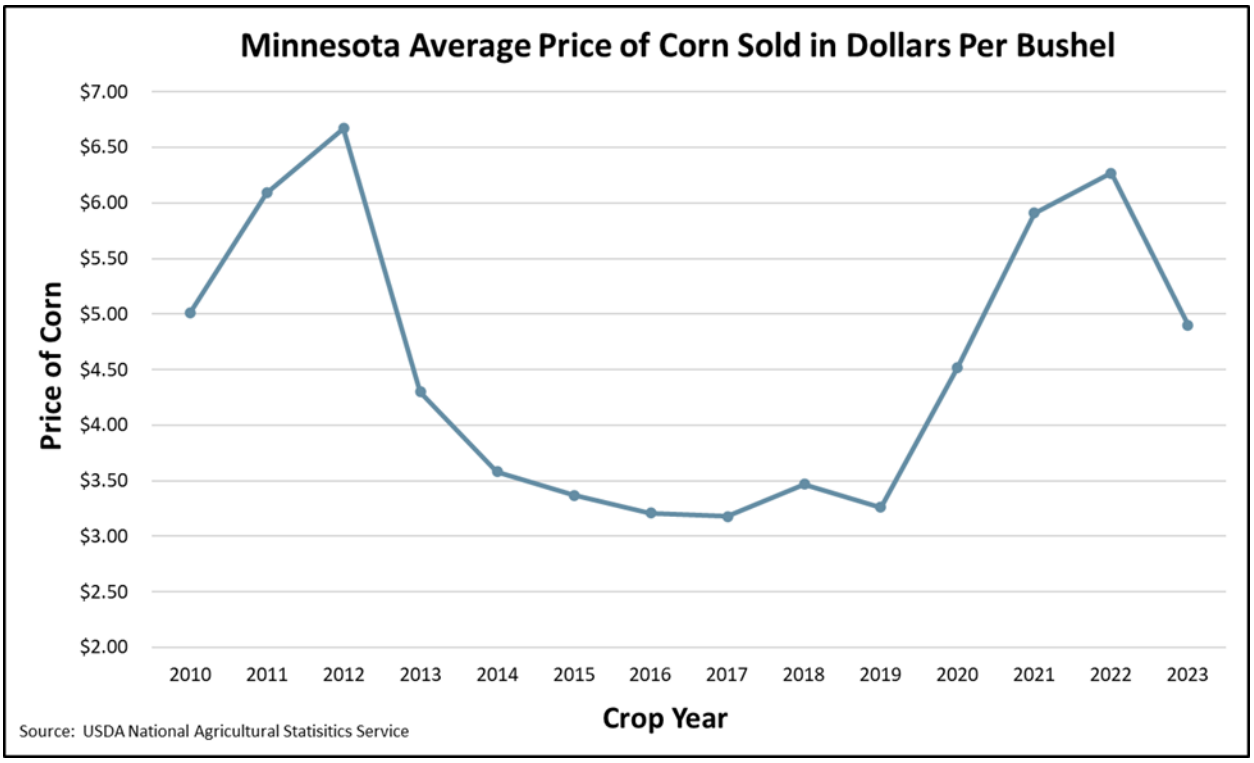

Figure 16. Minnesota price of corn per bushel sold from 2010 to 2023

Actual nitrogen from commercial fertilizer is applied before the crop is harvested[11]. Therefore, the price received for corn sold is not known at the time of the nitrogen application. Figure 17 details the annual average price per bushel of corn that farmers received, and the total tons of actual nitrogen sold.

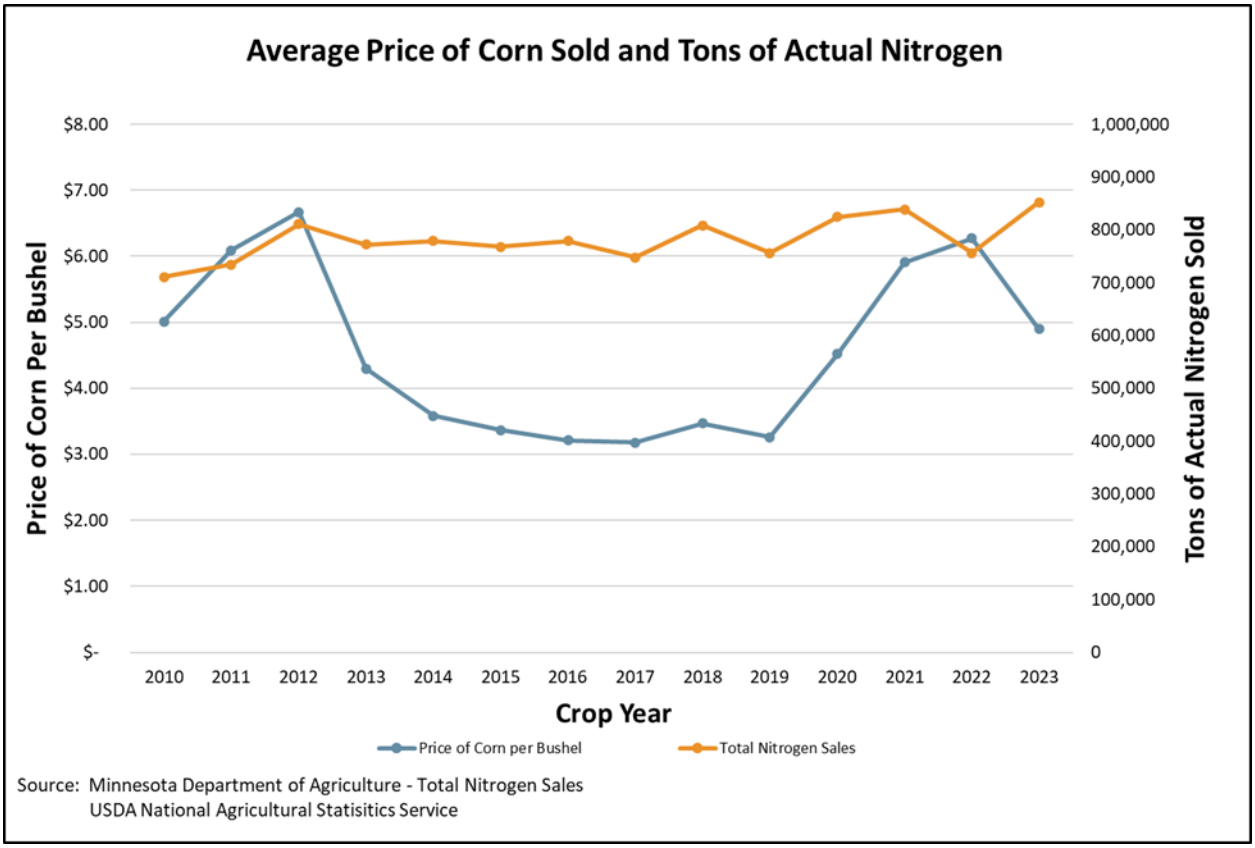

Figure 17. Minnesota price of corn per bushel sold and total tons of actual nitrogen sold from 2010 to 2023

[11] According to the Minnesota Department of Agriculture annual fertilizer survey, over 80% of the actual nitrogen applied to corn acres is applied in the preceding fall or preplant on corn acres in Minnesota.

Minnesota has an annual corn crop production from harvested acres for grain ranging from 1.2 billion and 1.6 billion bushels of corn as shown in Figure 18.

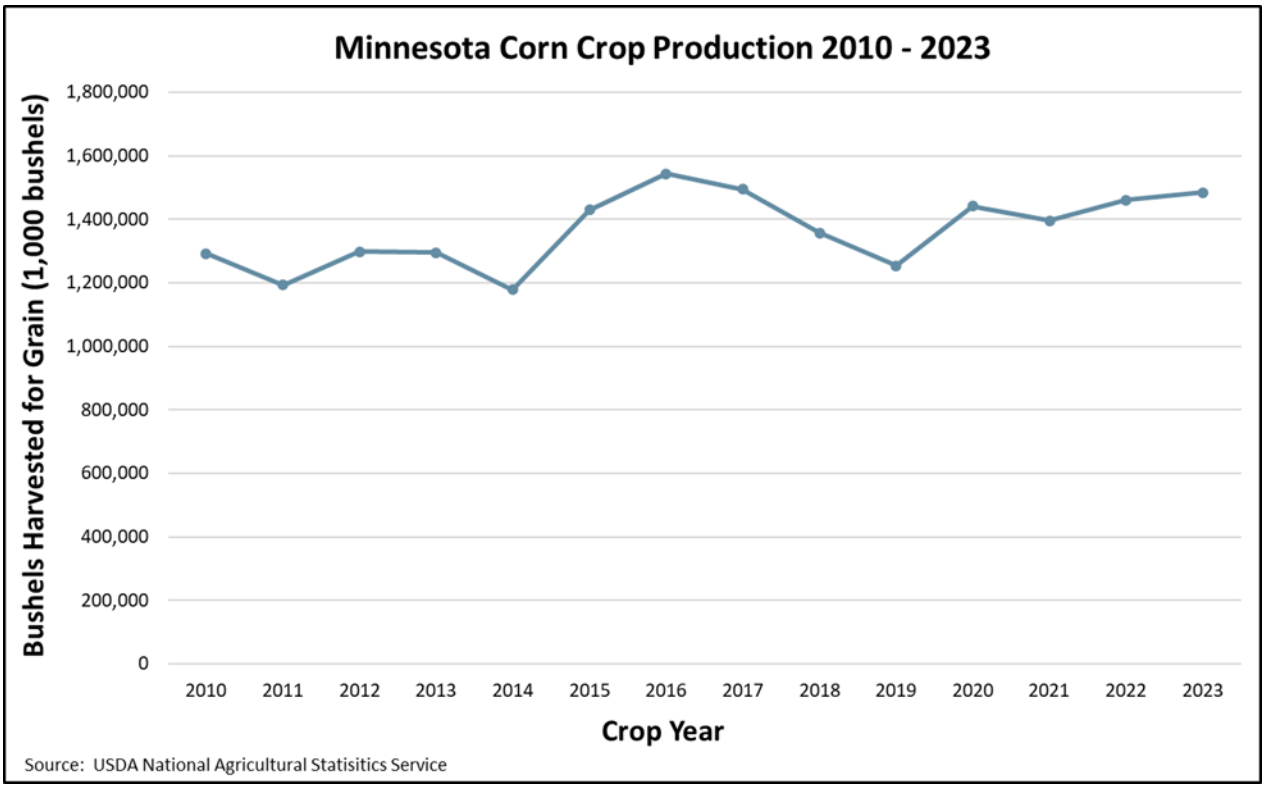

Figure 18. Minnesota harvested corn bushels from 2010 to 2023

Figure 19 details the total bushels of corn produced and the total tons of nitrogen sold. Nitrogen is applied months before the corn is harvested.

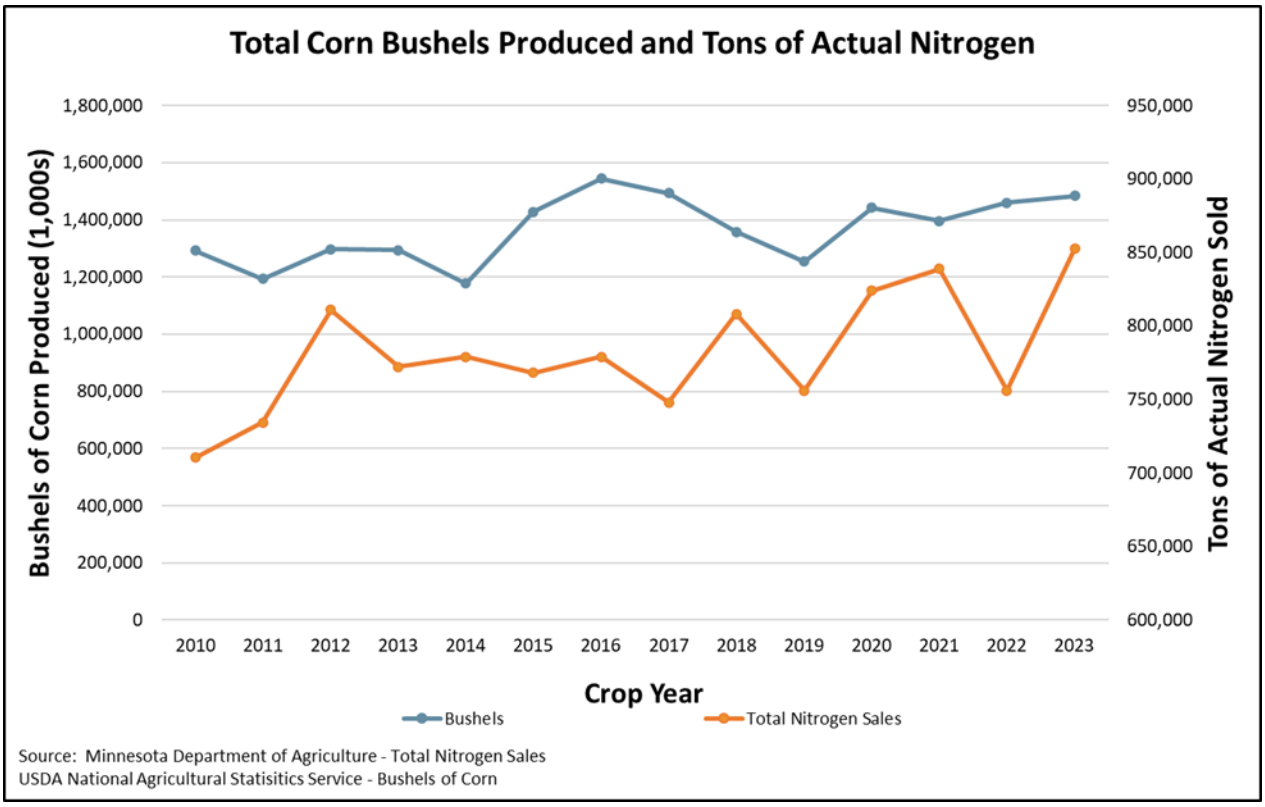

Figure 19. Minnesota corn bushels produced and tons of actual nitrogen sales from 2010 to 2023

Figure 20 shows that both bushels of corn produced and tons of nitrogen sold are increasing over time.

The figure below shows total tons of actual nitrogen sales in Minnesota and corn production. Silage corn, sweet corn and non-harvested corn are not represented in this figure.

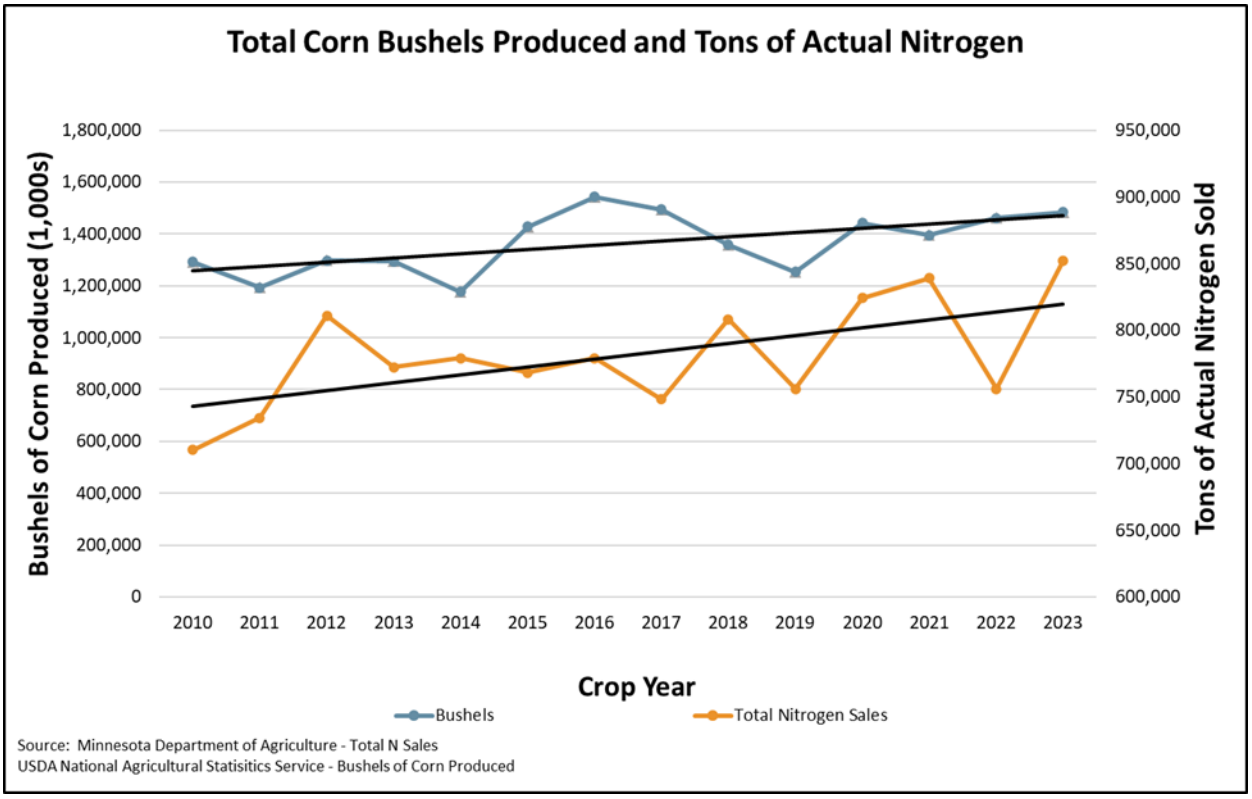

Figure 20. Minnesota harvested corn (bushels) produced and tons of actual nitrogen sales with corresponding trendlines from 2010 to 2023.

Nitrogen sales compared to the University of Minnesota's Maximum Return To Nitrogen (MRTN).

The University of Minnesota (UMN) has developed specific nitrogen recommendations for corn grown in Minnesota. These recommendations are detailed in the Fertilizing Corn in Minnesota publication. They are based on the price of corn and the price of nitrogen. Over the years the MRTN[12] approach has been used, the MRTN has generally been at 0.10. In this section the 0.10 MRTN will be used for analysis.

The UMN nitrogen guidelines[13] for fertilizing corn with actual nitrogen are based on the previous crop grown the year prior to the corn being planted. The USDA NASS is utilizing a satellite-based system

[12] The Maximum Return To Nitrogen (MRTN) is the price of nitrogen in $ per lb of actual N divided by the price of corn in $ per bushel. If the farmer purchased the actual nitrogen for his corn acres at the price of $.40 and they expect the price of corn to be $4.00 when they sells it at harvest, then the MRTN would be calculated: 0.4 / 4 = 0.10. MRTN would be 0.10. Footnote continues onto the next page.

[13] University of Minnesota guidelines for nitrogen are based on the MRTN and will be used interchangeably. They are located at: Fertilizing corn in Minnesota | UMN Extension

called Cropscape which can determine the crop grown on agricultural acres. Figure 21 details the corn crop by the previous crop grown prior to the corn from 2010 to 2022 using Cropscape. The 2023 crop data set has not been released so the following figures using crop history are only through 2022.

The University of Minnesota has separate guidelines for corn following alfalfa that does not include the MRTN. The MRTN for all corn following alfalfa was based on the high end of the recommended range for corn following two or more years of alfalfa[14].

Likewise, corn following other crops, including all crops that do not provide any nitrogen credits, (group 2) are calculated based on the guidelines from the UMN of those various previous crops[15].

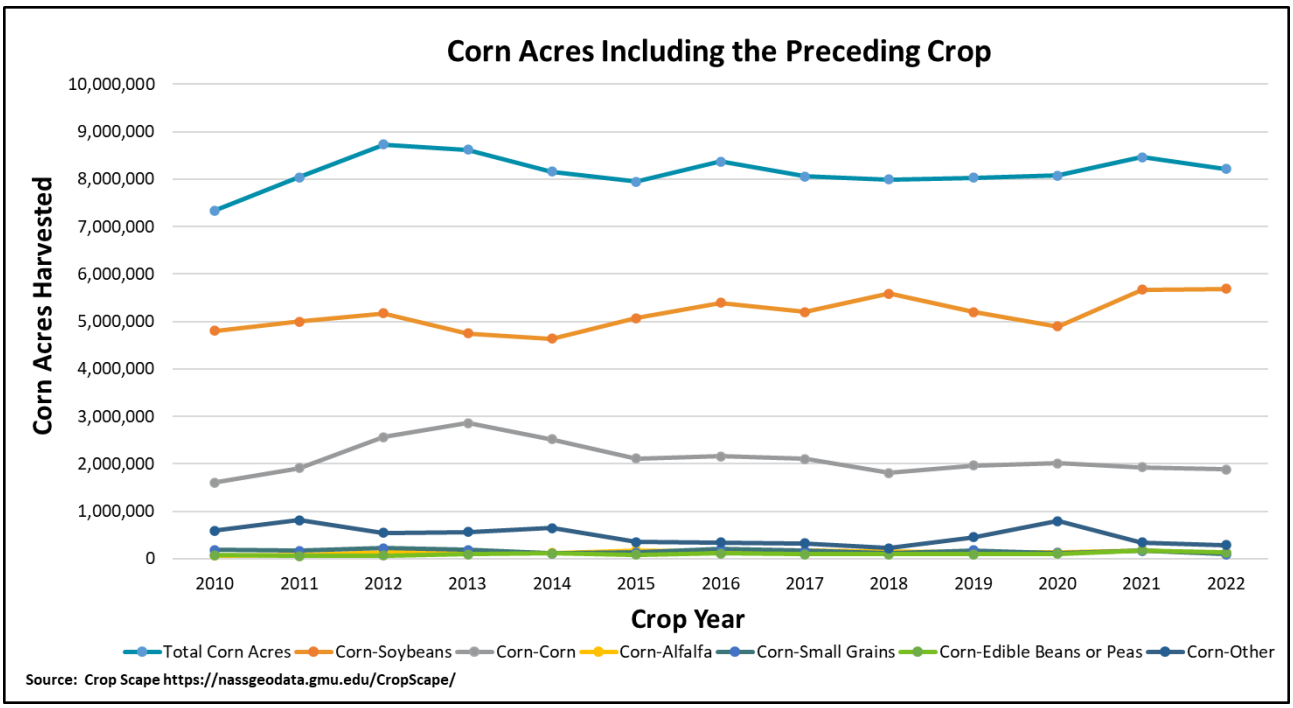

Figure 21. Minnesota corn acres by the previous crop grown from 2010 to 2022

[14] Taken from: Fertilizing corn in Minnesota | UMN Extension

[15] Taken from: Fertilizing corn in Minnesota | UMN Extension

Corn following soybeans and corn following corn account for approximately 90% of all corn acres, ranging from 86% to 93% from 2010 to 2022. Figure 22 details the corn acres in 2022 by previous crop[16].

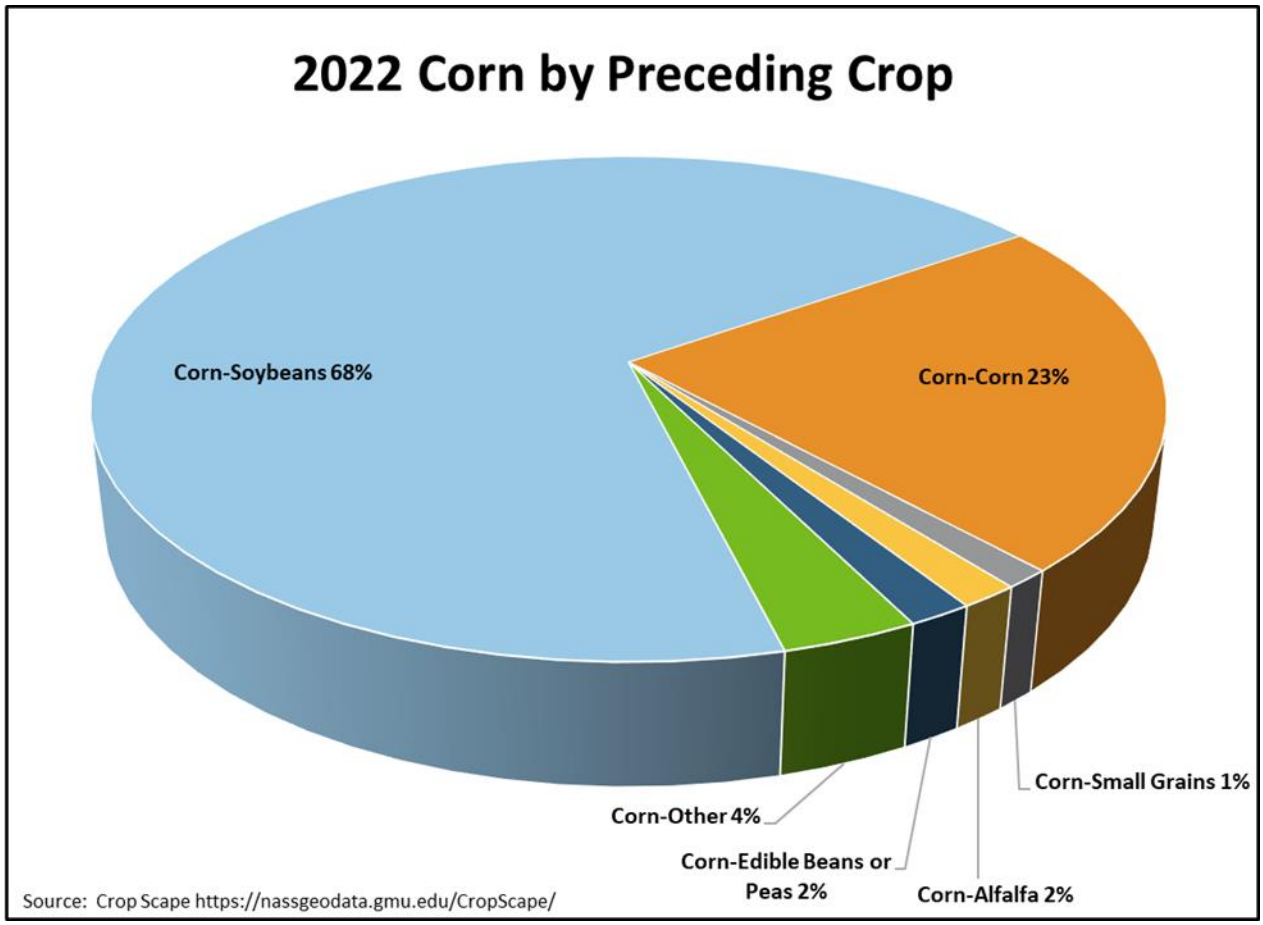

Figure 22. Minnesota corn acres by the previous crop grown for the 2022 crop year

[16] Corn-Corn would be corn following corn, Corn-Soybeans would be corn following soybeans, Corn-Other would be corn following other crops not listed in this chart, Corn-Edible Beans or Peas would be corn following edible beans or peas, Corn-Small Grains would be corn following small grains and Corn-Alfalfa would be corn following alfalfa. The corn would be the crop planted in 2022 and the previous crop would be planted in 2021.

The MTRN has increased over time. The MRTN was first used for University of Minnesota guidelines to determine nitrogen rates for corn acres in the 2006 crop year. The MRTN was held constant from 2006 to 2015. Beginning in 2015 increases in the MRTN were made for several crop rotations. Figure 23 compares the 0.10 MRTN for corn with previous crops between the 2015 and 2023 crop years[17].

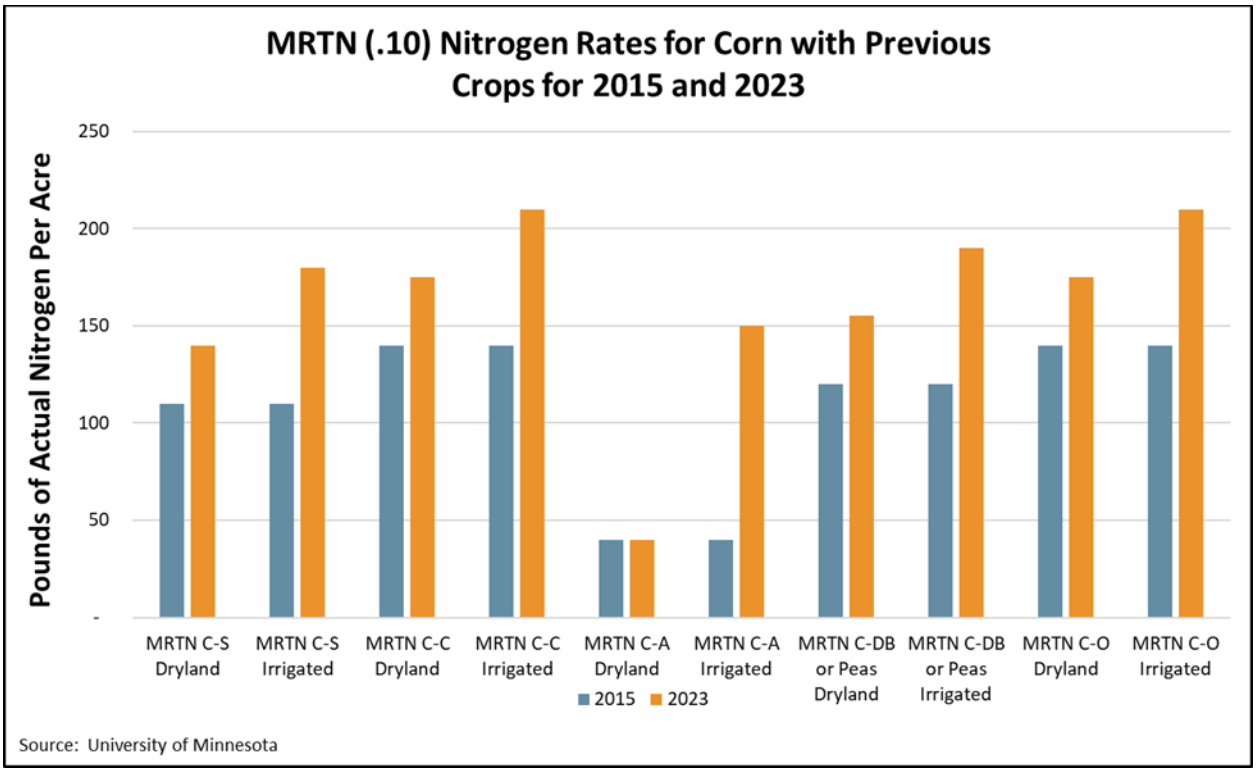

Figure 23. Minnesota 0.10 MRTN nitrogen rates for corn acres by the previous crop grown for the 2015 and 2023 crop years

[17] C-C is corn following corn, C-S is corn following soybeans, C-O is corn following other crops not listed in this chart, C-DB is corn following edible beans or peas. The corn would be the crop planted in 2022 and the previous crop would be planted in 2021.

Most dryland corn MRTN guidelines ranged between a 25% increase and a 29% increase. Dryland corn following alfalfa did not have an increase and dryland corn following dry beans or peas had the largest increase at 29%% as shown in Figure 24.

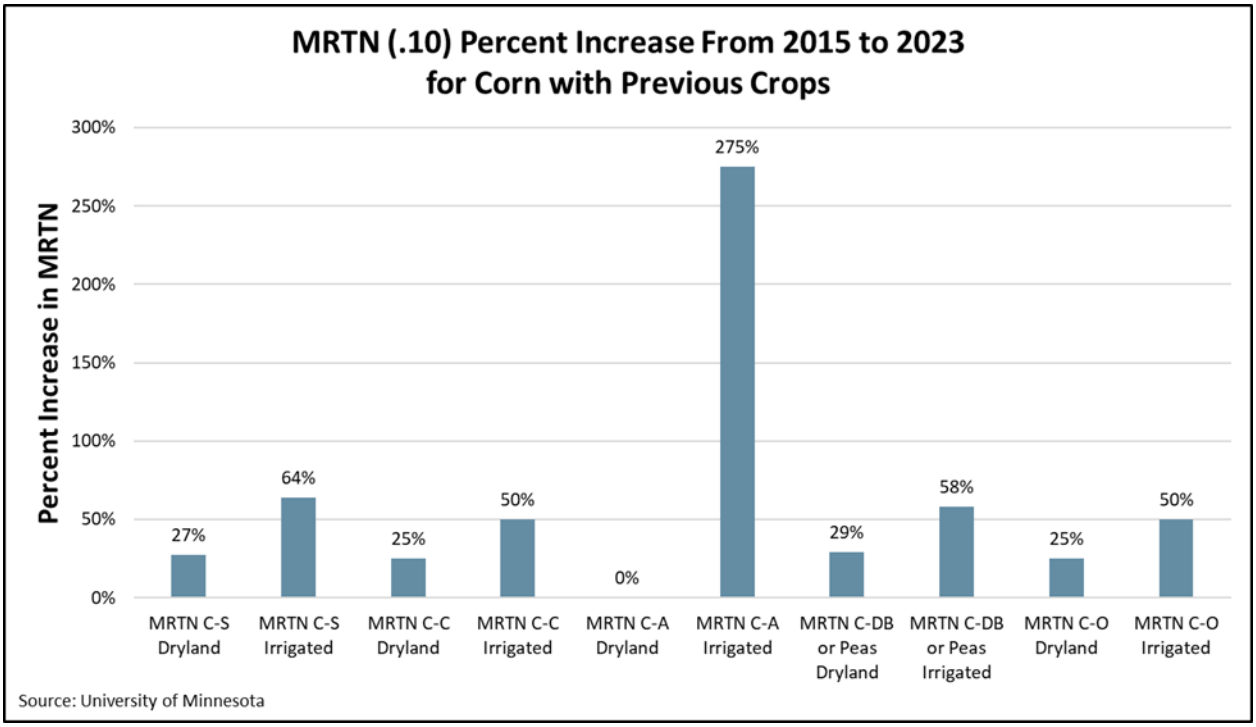

Figure 24. Minnesota 0.10 MRTN nitrogen rates guidelines for corn acres and percent increases by the previous crop grown when comparing the 2015 year to the 2023 crop year

Figure 25 details the total tons of nitrogen that is recommended based on the .10 MRTN for all corn acres and considering all previous crops. Second year credits of alfalfa are not considered. Previous crop is determined by the USDA CropScape and is then used for calculating the nitrogen recommended for the 0.10 MRTN or in the case of corn following alfalfa, the recommendations come from the Fertilizing Corn in Minnesota table for corn following alfalfa[18].

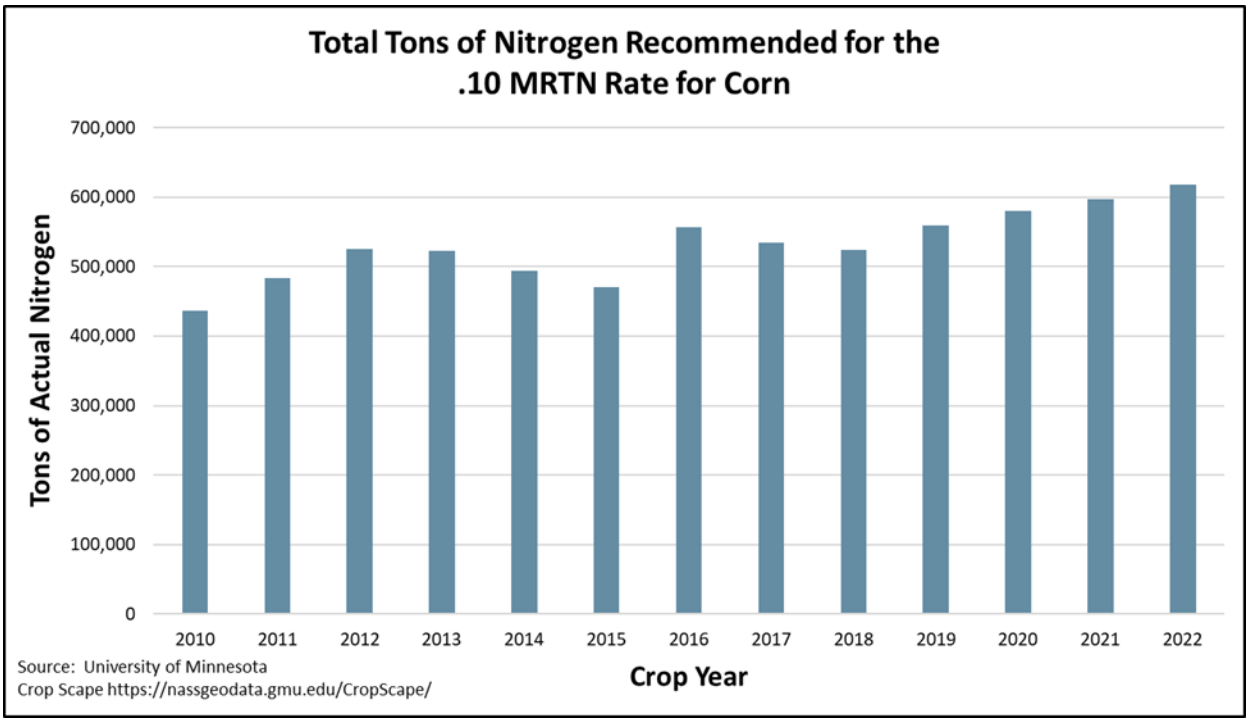

Figure 25. Total tons of actual nitrogen recommended for the Minnesota 0.10 MRTN rate for corn acres from the 2010 crop year to the 2022 crop year

[18] Fertilizing corn in Minnesota | UMN Extension

Tons of nitrogen recommended from UMN guidelines for nitrogen applied to corn acres planted in Minnesota has increased 41% from approximately 430,000 tons in 2010 to 620,000 tons in 2022.

Nitrogen recommended for harvested corn acres in Minnesota has increased while the harvested corn acres have remained relatively stable as shown in Figure 26.

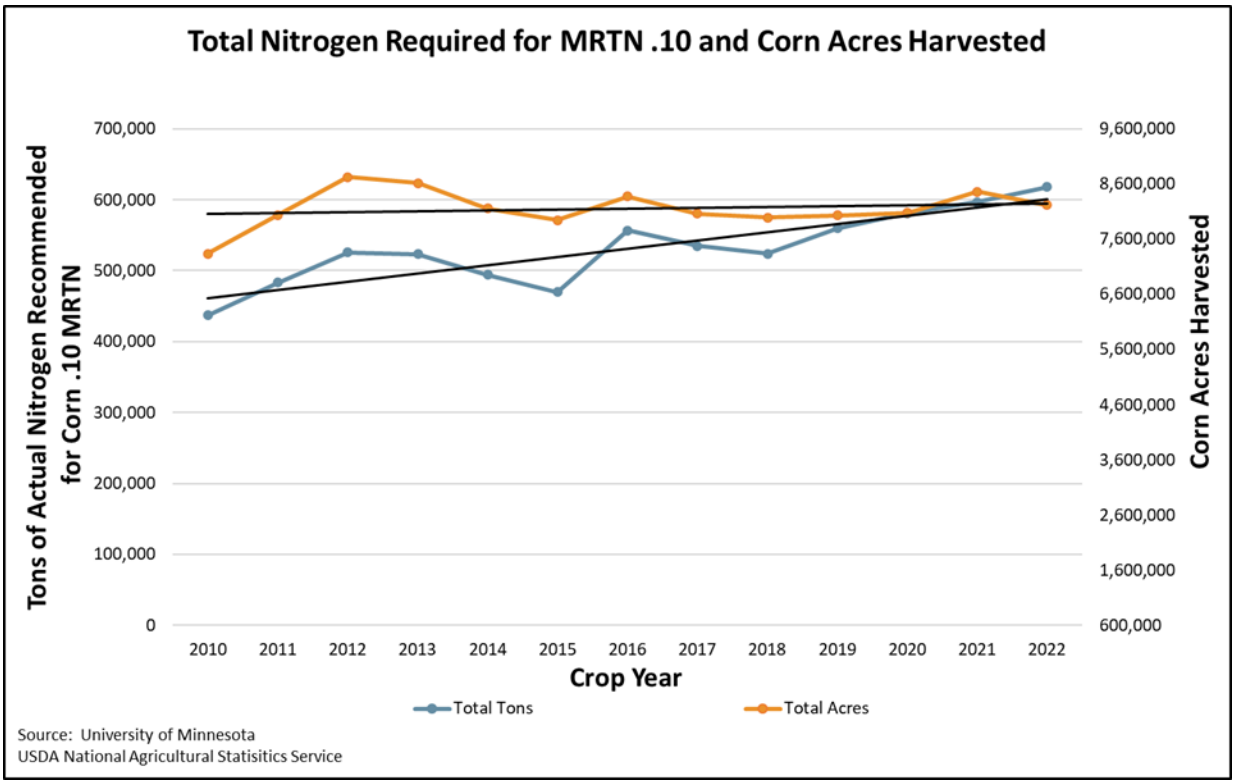

Figure 26. Total tons of actual nitrogen recommended for corn acres harvested from 2010 to the 2022 using the University of Minnesota 0.10 MRTN rates[19]

[19] Corn following alfalfa was based on table values from: Fertilizing corn in Minnesota | UMN Extension

Figure 27 details the increase in actual nitrogen sales and the increase in nitrogen recommend from the UMN guidelines for corn in Minnesota.

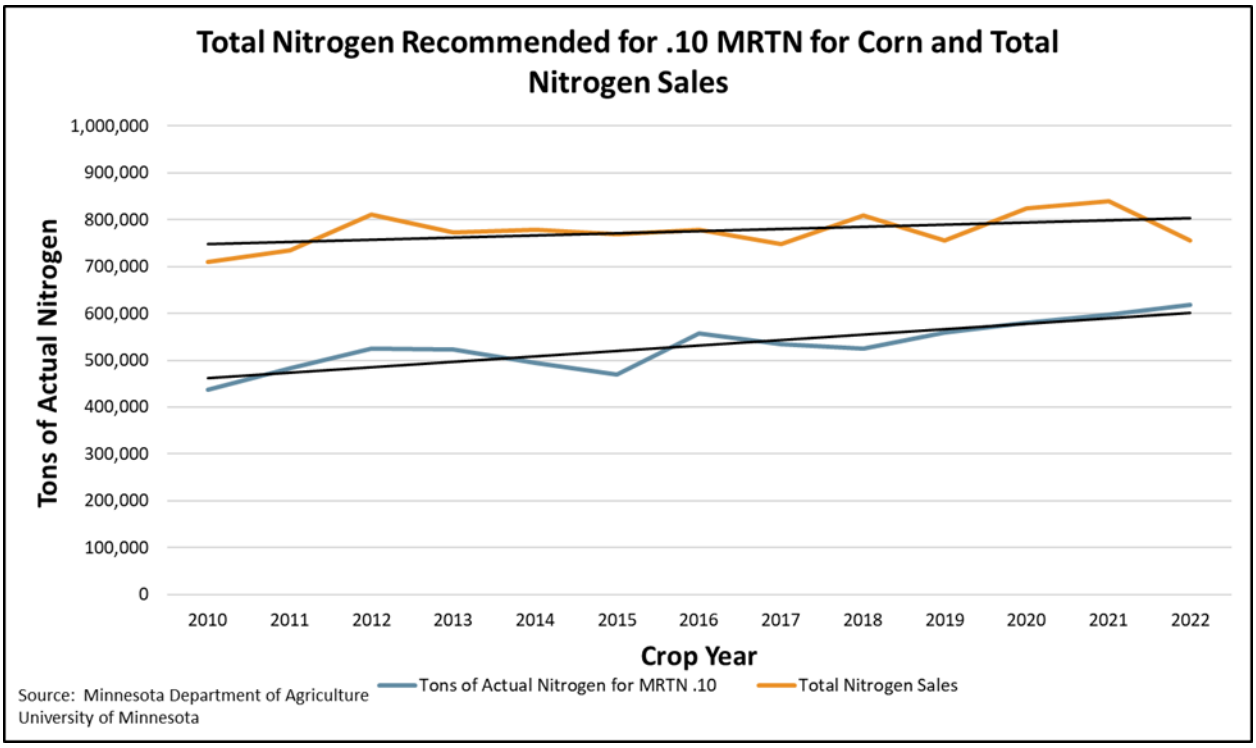

Figure 27. Total tons of actual nitrogen recommended for the Minnesota 0.10 MRTN nitrogen rates for harvested corn acres from the 2010 crop year to the 2022 crop year

In 2010, the actual nitrogen recommended from the UMN guidelines for all harvested corn acres accounted for 60% of actual nitrogen sales. In 2022, the actual nitrogen recommended from the UMN guidelines for all harvested corn acres accounted for 78% of actual nitrogen sales.

Figure 28 details the percent of total actual nitrogen sales needed to achieve the recommended 0.10 MRTN[20] for corn each year from 2010 to 2022.

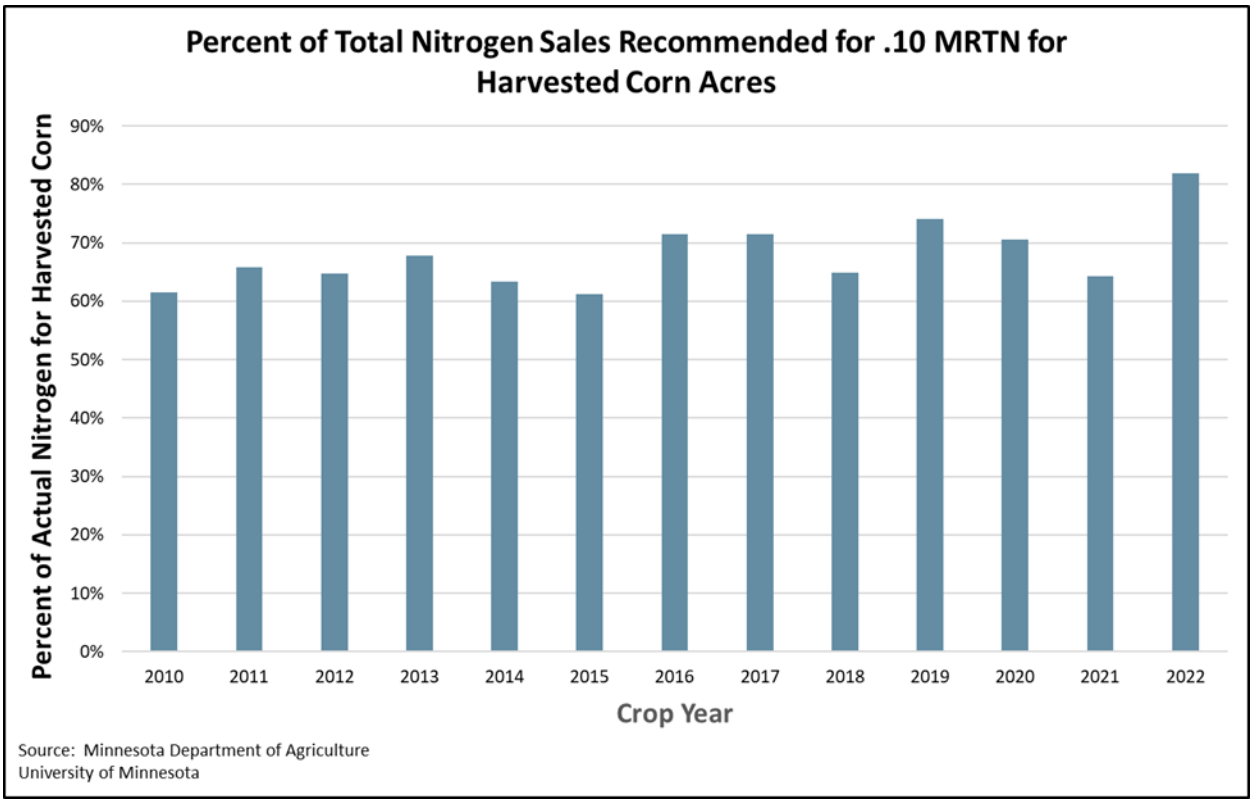

Figure 28. Percent of total tons of actual nitrogen sold needed to achieve the recommended Minnesota 0.10 MRTN nitrogen rates for harvested corn acres from the 2010 to 2022

[20] Corn following alfalfa was based on table values from: Fertilizing corn in Minnesota | UMN Extension

Conclusions

The MDA nitrogen yearly sales data may not represent the actual amount of nitrogen that is applied to Minnesota crops in any given year. Farmers often prepay for nitrogen in the fall before the crop is planted based on intended acres. Weather events can also affect nitrogen applications, and some purchased nitrogen may not be applied in the crop year that it was purchased. Minnesota farmers may be applying some of the nitrogen on farms outside of Minnesota and some out of state farmers may be applying nitrogen in land that they farm in Minnesota. All the above factors can contribute to yearly fluctuations in nitrogen sales.

Sales of corn can also be based on actual sales of crop or the corn can be sold on the futures market for a price and delivered on the futures date. Farmers can and do sell a high percentage of their corn crop on the futures market. In December 2023 it was estimated that over 50% of the corn crop was sold for the 2024 crop year.

Farmers who base the nitrogen to be applied for the coming crop year must also estimate the corn price and yield to calculate any Maximum Return To Nitrogen (MRTN) if that is used to determine the yearly nitrogen rate.

It appears that on any given year many factors contribute to the amount of nitrogen that is sold in Minnesota. The intent of this report is not to make assumptions as to what is the driving force that determines nitrogen sales for a given year but to provide the reader with a variety of variables that may contribute to or influence the sales of nitrogen.

This document also excludes any contributions of manure as a source of nitrogen or the influence that nitrogen source may have on fertilizer sales.