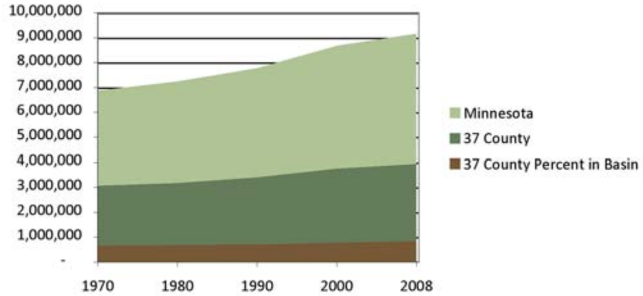
Population Trends

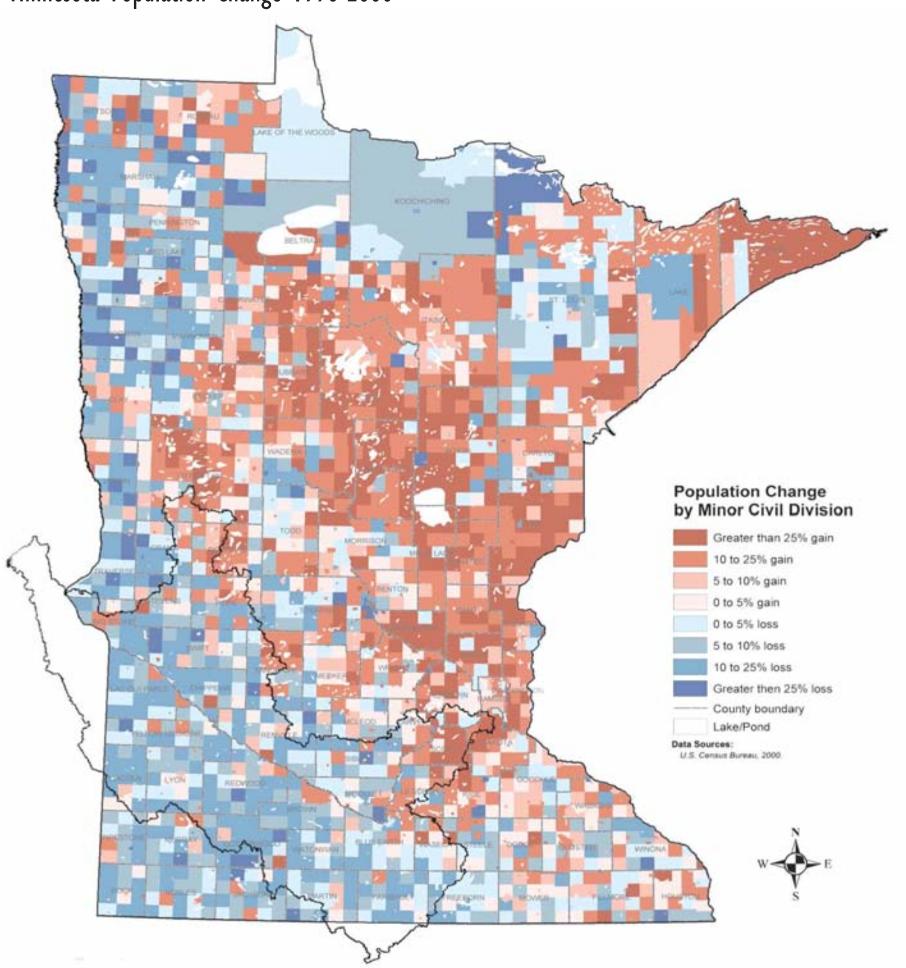
Urban areas on the rise—Rural areas declining

Minnesota & Minnesota River Basin Population 1970-2008



As the graph above shows, population growth has been more rapid across the state of Minnesota than within the 37 county Minnesota River Basin from 1970 to 2008. The Population Change map below illustrates the change in population between 1990-2000. The vast majority of the basin is in blue, indicating a decrease in population over the decade. The table at right underscores the overall pattern depicted on the map with metro-area counties Scott, Carver and Dakota illustrating significant increases in population while many south western counties show continuing population declines.

Minnesota Population Change 1990-2000



Map Source: Minnesota Planning

County Population Change 1990-2000

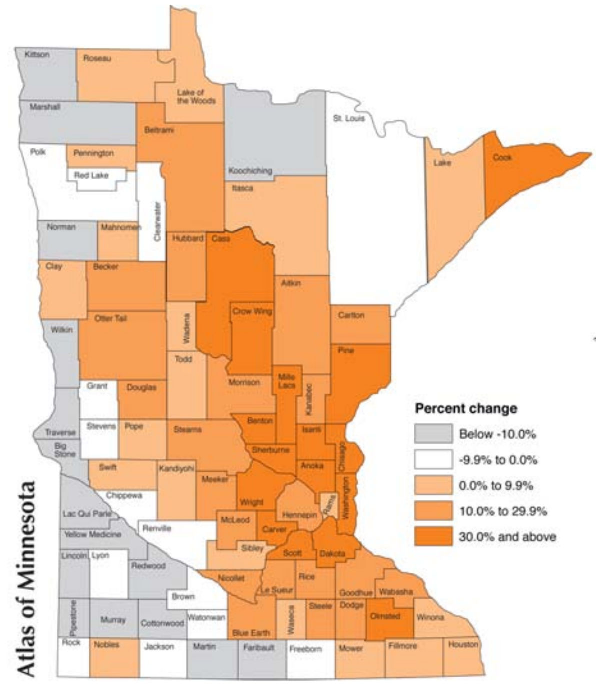
County	Percent Change
Scott	54.72
Carver	46.52
Dakota	29.31
Rice	15.21
Douglas	14.46
Otter Tail County	12.71
Stearns	12.10
Swift	11.49
Steele	9.60
Le Sueur	9.41
McLeod	8.95
Hennepin	8.11
Waseca	8.00
Sibley	6.89
Kandiyohi	6.30
Nicollet	6.04
Ramsey	5.20
Pope	4.57
Blue Earth	3.51
Lyon	2.57
Watonwan	1.66
Grant	0.69
Martin	-0.05
Murray	-0.05
Brown	-0.27
Chippewa	-1.06
Freeborn	-1.44
Redwood	-2.54
Renville	-2.94
Jackson	-3.50
Cottonwood	-4.15
Faribault	-4.46
Yellow Medicine	-5.17
Stevens	-5.46
Pipestone	-5.68
Lincoln	-6.69
Traverse	-7.37
Big Stone	-7.40
Lac qui Parle	-9.60

Urban
Population growth in the suburbs

The Minnesota Population Change map (at right) shows Minnesota's population change from 1990-2007. Over that time period, the state grew an estimated 822,500, from 4.4 million to 5.2 million, but that growth was not evenly spread throughout the state. Growth in the suburban counties that ring the Twin Cities (dark orange on the map indicates greater than 30% gain) stands out. Counties within 50 to 75 miles of the Twin Cities showed dramatic growth, especially Carver and Scott counties. Scott County, for example, has more than doubled from 1990-2005. On the other hand, smaller cities and townships across the southwestern portion of the state have been losing population. Population loss (grey and white) is shown across a large swath of the basin (Center for Rural Development and Policy, 2008).

In recent decades, the Minneapolis-St. Paul metropolitan area's growing economy has attracted new residents and stimulated urban growth. From 1990-2000, the population of the core seven counties — Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington — grew from 2.28 to 2.64 million (Yuan et al., 2005). Another study reported that from 1974 to 2000 the population of the seven-county metro area increased by 38 percent while the urban land area increased by 59 percent (EPA, 2003). This expansion of low-density suburbs into formerly rural areas have environmental impacts on air and water quality and loss of farmland and forests.

Minnesota Population Change 1990-2007



Source: Center for Rural Policy and Development, 2008

Urban Development & Impervious Surfaces

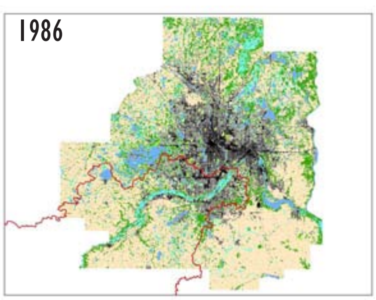
Remote sensing techniques enable researchers to show urban development by mapping changes in impervious surfaces. Impervious surfaces are those that water cannot infiltrate (rooftops, streets, highways, parking lots). The amount of impervious surface directly affects the amount of runoff to streams and lakes, and impacts the water quality of area lakes and streams. Metro area maps (below) show dramatic changes from 1986 to 1991. The seven-county metro area, the percentage of impervious area increased from 9 percent in 1986 to 13 percent in 2002. The greatest changes occurred in Anoka and Carver Counties, where the impervious surface area more than doubled (Manson et al., 2006). Beyond the metro area (maps below), urban development and increased impervious surfaces are concentrated in a few medium and small sized cities visible in pink on the maps below. Outside the Metro Area, only a few counties are registering growth rates comparable to the Twin Cities.

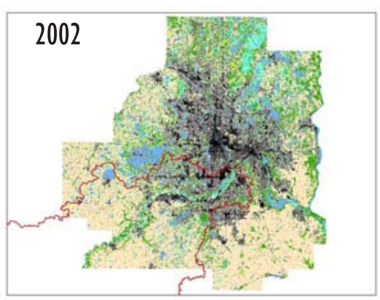
Metropolitan Design Center

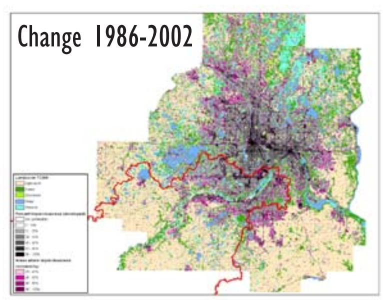
Eden Prairie Housing Development and the Minnesota River

Metro Area Impervious Surface

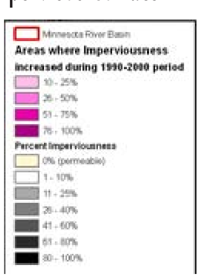
Maps Courtesy of University of Minnesota's Remote Sensing and Geospatial Analysis Laboratory. Pink color denotes a higher degree of impervious surface area.

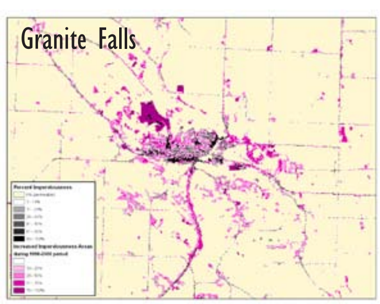


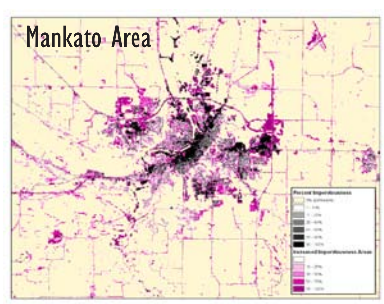




Outside Metro Area Impervious Surface Change 1990-2000







Rural
Southwestern Minnesota counties see an ongoing population decline

Historic Rural Demographic Trends

The population of many rural counties in southwestern Minnesota peaked in 1940 after the devastating Great Depression and the onset of World War II pushed many people to move for economic reasons. In addition, young men and women who served in the military and the war production effort were drawn to urban areas that offered higher wages and educational opportunities. For counties like Lac qui Parle, Lincoln and Yellow Medicine there has been a continuing decline since the 1940 census as their population grows older and fewer jobs are available for younger people.

According to the USDA Economic Research Center, per-capita incomes and high school graduation rates for rural areas lag behind urban centers, while poverty and unemployment numbers are higher. Rural areas have a harder time creating new businesses and jobs as "Minnesota shifts from a manufacturing-based economy to one that is more technological, global, service-oriented and knowledge-based," reports Minnesota Planning.

Outmigration of Young People

Fewer opportunities for employment, higher education and social amenities have been identified as the major reasons young people leave rural areas along with low wages and the lack of affordable housing. In the 1990s, 21 counties in Minnesota lost population, predominately in the west and south. This out-migration of young people has resulted in a "disproportionate and rising percentage of elderly people in these rural communities." Minnesota Planning expects this trend to continue.

Concentration of Elderly Residents

The greatest concentration of older residents is found in the southwestern part of the state. Traverse County has the highest percentage of elderly residents at 26.2 percent followed by Lincoln at 24.4 percent and Lac qui Parle at 23.2 percent, reports the Minnesota Demographic Center. A 2000 Census Portrait stated, "The largest concentrations of elderly people are rural areas that have experienced out-migration of young people, mirroring the same dynamic that occurs among many western states."

Population Projections

Over the next 20 to 30 years, rural counties in southwestern Minnesota are projected to continue losing population including Lac qui Parle, Lincoln and Yellow Medicine.

- Lac qui Parle is expected to see negative 9.6 percent growth rate from 2005 to 2015 and a 15 percent decrease from 2015 to 2035.
- Lincoln will see less of an impact with a negative 3.1 percent and 2.9 percent decrease, while
- Yellow Medicine has a projection of negative 5.4 percent growth rate and 9.0 percent decrease from 2015 to 2035 (Minnesota State Demographic Center, 2007).

Scott Kudelka

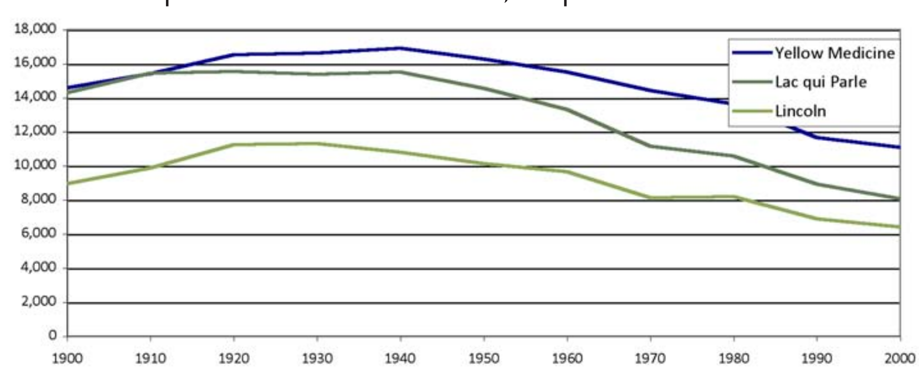
Downtown Dawson, Lac qui Parle county.

The abandoned farmstead is only a building site. Many of these abandoned farmsteads have been removed to be converted to cropland.

Dave Craigmile

Abandoned farm in Lac qui Parle county.

Population 1900-2000: Yellow Medicine, Lac qui Parle & Lincoln counties

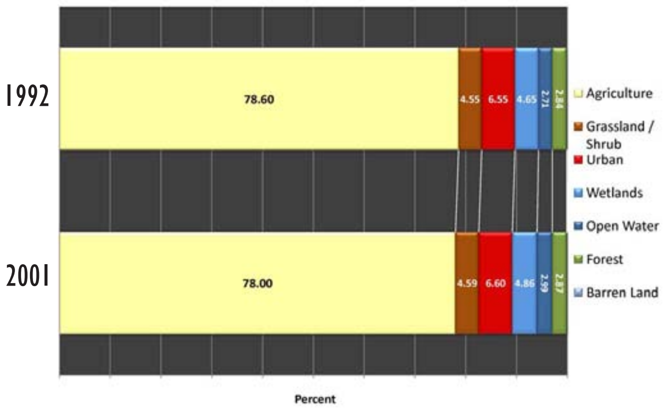


Farm Land Predominates

Agricultural production dominates basin land use

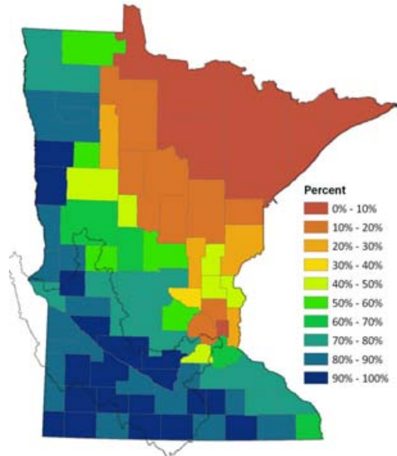
Ron Boldtuan

Land Use Change in Basin 1992-2001



Source: Minnesota Agricultural Statistics

Land in Farms 2007



Source: Minnesota Agricultural Statistics

Land Use

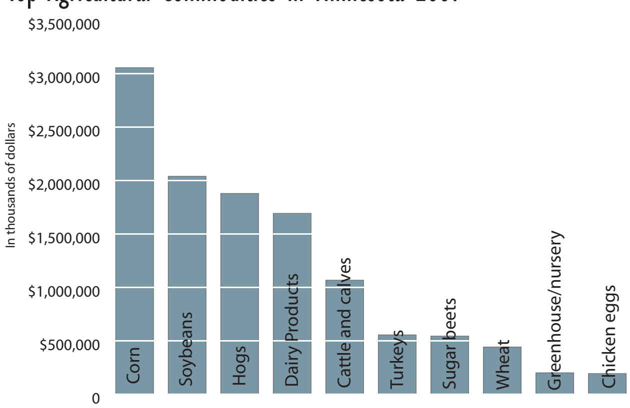
Today row crop agriculture is the predominant land use in the basin. The Minnesota River Basin consists of 10.85 million acres (9.5 million acres within Minnesota). In 1992, there were 8.52 million acres of agricultural land (78.6%). In 2001, there were 8.46 million acres of agricultural land (78%). Other land uses include grassland/shrub, urban, wetlands, open water, forest, and barren land. Notable changes in land use from 1992-2001 include a slight decrease in agricultural lands and an increase in wetlands, open water, and urban lands. The amount of land in crops remained relatively stable over the same time period.

The Minnesota River Basin is one of the most productive agricultural regions in the state. The basin stands out statewide as a region with a higher percentage of land in farms (see map above).

Craig Anderson, MDNR

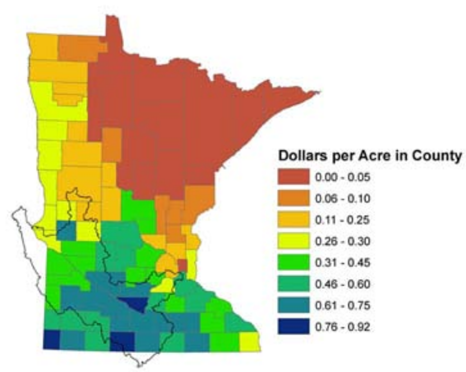
Remnant prairie and the Pomme de Terre River amidst an agricultural landscape

Top Agricultural Commodities in Minnesota 2007



According to the 2007 U.S. Census of Agriculture, Minnesota Farms generated $13.2 billion (market value) in agricultural products, with 53 percent in crops, vegetables, nursery crops and other related crops, and 47 percent in livestock, livestock products and poultry. Together these farms help Minnesota rank as the seventh top agricultural producing state in the nation. As the "Market Value" map at right shows, the Minnesota River Basin is a top-producing region.

Market Value of Agricultural Commodities 2007



Farm Size and Number

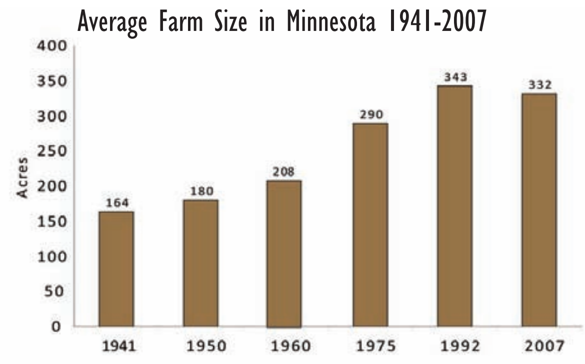
Fewer and larger farms

Over the last two decades, there have been two distinct trends—a rapid decrease in the number of small farms and production concentrated in fewer farms with increased level of production. New technology have lead to significant changes in agriculture. Each producer now raises more crops and livestock than ever before. These changes have effected people directly involved in agriculture but also rural communities across the basin (EQB, 1999).

How many people does the average farmer feed?

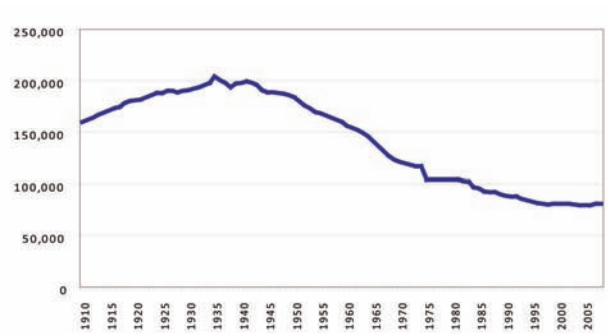
Today, the average American farmer feeds 130 people. In 1960 a farmer fed just 26 people. In 1919, a farmer could feed his family and 12 others (NAWG, 2008).

Average Size of Farms Increasing



Number of Farms in Minnesota Decreasing

Number of Farms in Minnesota 1910-2006



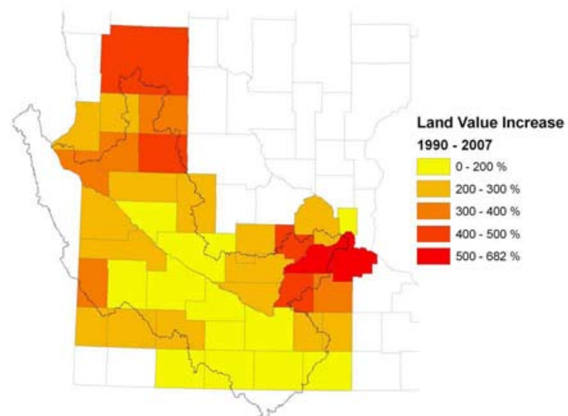
In the Minnesota River Basin, farm size has increased while the number of farms has decreased over time (see graphs above). This has resulted in people leaving rural areas in some parts of the Minnesota River Basin (see demographics section).

Microtrend: Farmer's Markets

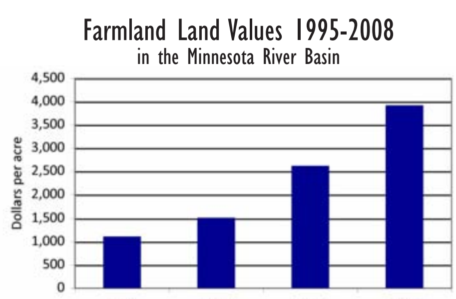
New Ulm Farmer's Market

In the last few years there has been an increase in the number of farmer's markets throughout the state. The number of farmer's markets in the Minnesota has tripled in the past five years with close to 130 operating in both rural communities and metro areas. In the Minnesota River Basin there are around 35 farmer's markets from Ortonville to the Twin Cities who offer their products directly to the consumer.

Land Value Increasing



The map above illustrates the change in land values from 1990 to 2007 across the Minnesota River Basin. In recent years, demand for farmland for residential and commercial development has driven up values, as can be seen in the urban and suburban counties of the Twin Cities and the lake-rich counties in the north. The graph below shows the average farmland land values in the Minnesota River Basin. The average value for Minnesota farm land in 2008 was $3,923 per acre, compared to $2,619 in 2005 and $1,114 in 1995 (Minnesota Land Economics, 2009).

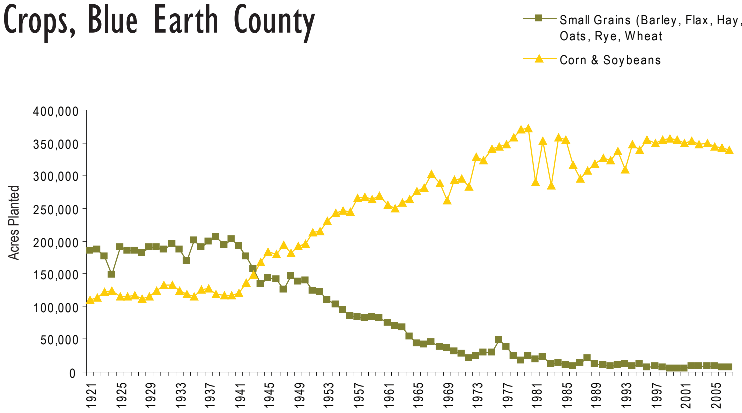


Source: UM Minnesota Land Economics

Crop Types & Farming Practices

Types of cops have changed over time—from mixed to predominantly corn and soybean

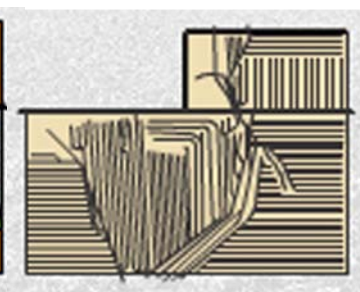
Crops, Blue Earth County



The types of crops grown throughout the Minnesota River Basin have changed over time from a diverse array of crops to predominantly corn and soybean. A farm-scale case study in Mapleton Township in Blue Earth County illustrates these changes over time (Burns, 1954). The graph at left shows the shift from small grains (barley, flax, hay, oats, wheat) to corn and soybeans that occurred in the 1940s. This post-WWII shift to corn and soybean dominance echoes the trend across the basin and the broader midwest US.

Types of Crops, Blue Earth County

1937
This 400-acre farm is on flat land with poorly drained soils. Diverse crops include oats, alfalfa, pasture, wild hay, barley, and corn. Note depressional sloughs or "potholes" dotting the landscape.



1948
The tile system was installed in 1948. It was estimated that 38,000 feet of tile were laid on this 400-acre farm.

1952
By 1952 soybeans and corn are planted on a larger portion of the farm along with pasture, peas, winter wheat, alfalfa, oats and flax.

2005
Aerial photos of the farm from the 1960s to present shows the farm predominantly in corn and soybean rotations.

www.mccormick-deering.com

BNC Water Quality Board

www1.caseih.com

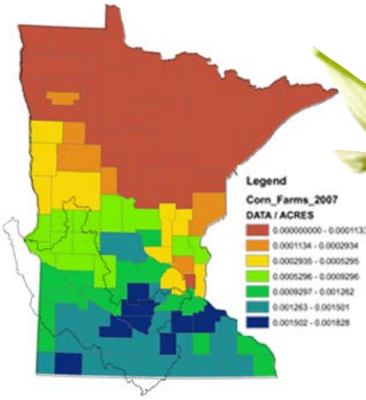
Minnesota Soybean

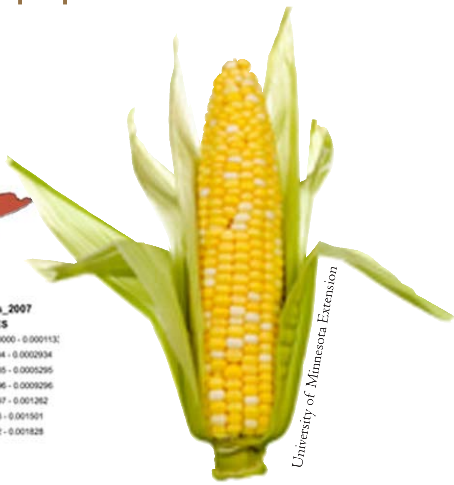
Minnesota Soybean

Corn & Soybeans

Corn and soybean crops predominate

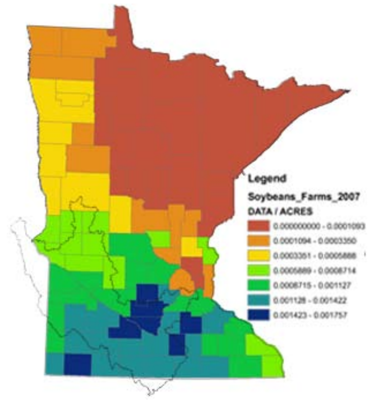
Farms in Corn 2007





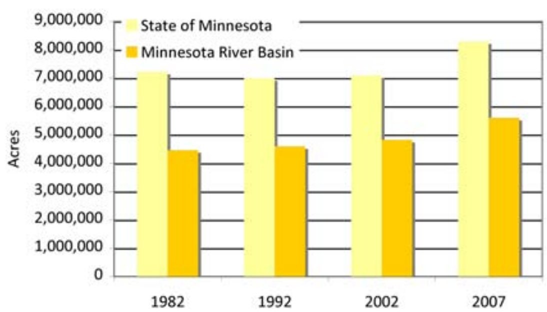
University of Minnesota Extension

Farms in Soybean 2007

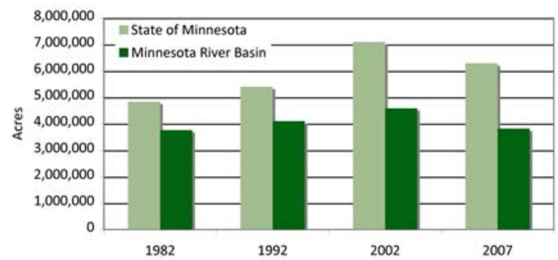


Minnesota Soybean

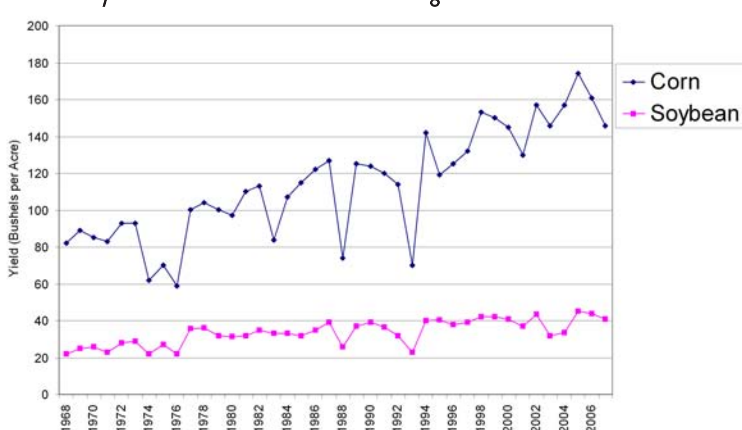
Corn Acres Harvested



Soybean Acres Harvested



Corn and Soybean Yields: Minnesota State Average 1968-2007



Corn Density and Yield

1920s 8,000 plants per acre
Yield: 20 bushels per acre

Late 1930s Hybrid seed comes on the market that is bred to produce thicker stalks and stronger root systems to stand better upright in a crowd and withstand mechanical harvesting.

1950s 12,000 plants per acre (LeBaron, 2008)
Yield: 70-80 bushels per acre

Today 30,000 plants per acre
Yield: 200+ bushels per acre (Pollan, 2006)

Corn Yields Show Dramatic Increases

The graph below illustrates the dramatic increase in corn yields from 1968-2007. According to University of Minnesota agronomist D.R. Hicks, increased corn yields are due to the combination of higher yielding hybrids, good weed control, good fertility programs, higher plant populations, earlier planting, and weather factors (Hicks, 2006).

Scott Kudelka

Minnesota Soybean

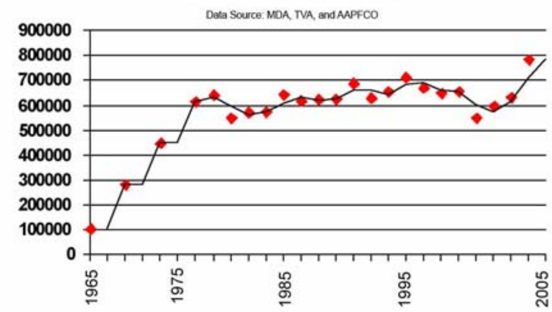
Fertilizers

MDA

Nitrogen

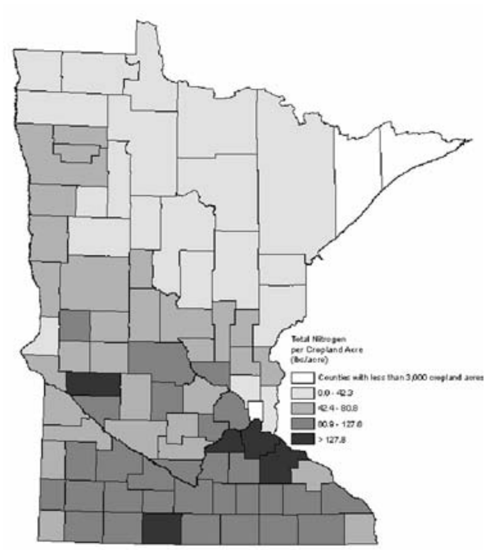
Post WWII there was an explosion of commercial fertilizer use across the US. The statewide fertilizer sales graph at right provides an indication of Nitrogen rates used by producers. Total annual Nitrogen sales in Minnesota during the same time period increased from 100,000 to 600,000 tons (Montgomery, 2008). This echoes the broader trend across the US as Nitrogen fertilizer usage rapidly increased from approximately 40 lb Nitrogen per acre from 1965 to 110 lb Nitrogen per acre in 1988 (Tennessee Valley Authority, 1988).

Commercial Nitrogen Fertilizer Sales Trends
in Minnesota 1965-2004



Source: Montgomery, DATE

Nitrogen Input Estimates



The map above depicts nitrogen input estimates based on 2002 Census data for county nitrogen fertilizer sales (point of sale), "fertilizer replacement" credits from manure and legume contributions. Inputs are averaged across all cropland acres within each county (Birr et al, 2008). The Minnesota River Basin stands out as a region with higher nitrogen inputs.

Did You Know?

At the end of World War II the federal government scrambled to find a use for the vast amounts of ammonium nitrate stockpiled from making explosives for the war effort. As a result, munitions plants were converted into chemical fertilizer plants for agricultural crops (Pollan, 2006).

Sources of Nitrogen

The primary sources of nitrogen in Minnesota's surface waters include: fertilizers, animal manure, municipal sewage wastes, agricultural and industrial wastes, atmospheric deposition, and dinitrogen fixation (as well as naturally occurring nitrogen) (Randall, Mulla, 2001). The transport of nitrate-N to surface waters can occur through base flow or subsurface drainage systems. The amount of drainage water leaving the landscape largely depends on climate and soil properties. Researchers frequently identify agriculture as a major contributor of nitrate-N to surface water. A common theme among numerous studies is that agricultural N remains a major component of total N export to rivers in the basin (Montgomery, 2002).

Farm Scale Study

A 2007 farm study in Seven Mile Creek Watershed can serve as an example of nitrogen use in the basin. Eighteen farms totalling 9,183 acres of farmland were inventoried for the study. Corn acres accounted for 99 percent of the nitrogen applied and 100 percent of the manure applications.

Field corn accounted for more than 92 percent of the pounds of commercial nitrogen (N) fertilizer applied on the farms studied. Nitrogen applications to corn averaged 157 pounds per acre (see graphic below). All field corn acreage received either commercial N fertilizer or manure. Field corn received most of the N with 99 percent of the total applied. Field corn yield goal for these farms averaged 182 bushels per acre (Bu/Ac) and were consistent with the five-year historical averages of 172 Bu/Ac (MDA, 2007).

Nitrogen Applied on Corn Acres
Average for Seven Mile Creek Watershed 2007

157 lbs of Nitrogen applied per acre	Commercial Nitrogen 125 lbs	82% Anhydrous Ammonia 9% Liquid & Urea 6% MAP/DAP
	Manure 32 lbs	42% Dairy / 58% Hog

Phosphorus

Phosphorus is a chemical commonly found in soil, rocks and plants. It is an essential nutrient for plant growth and therefore is an important fertilizer in agricultural production and widely applied across the Minnesota River Basin (see map below). However, phosphorus is also an important contaminant of surface water since even low concentrations can lead to algal blooms (eutrophication). Elevated phosphorus levels is the primary cause of algal growth which is a leading contributor to low dissolved oxygen concentrations in the lower twenty-two mile reach of the Minnesota River during low flow conditions. Further downstream, elevated phosphorus levels can contribute to eutrophication of Lake Pepin. At a national scale, eutrophication is responsible for the hypoxic zone (area of low oxygen) in the Gulf of Mexico (see "Downstream Impacts: Nitrates and the Dead Zone" section for more information).

Sources of Phosphorus

The MPCA approximated primary sources of phosphorus to the Lower Minnesota River as part of Lower Minnesota River Dissolved Oxygen TMDL. Primary sources of Phosphorus included: Wastewater Treatment Facilities 65 percent, Urban stormwater 16 percent, Agriculture 14 percent, direct discharges of sewage 4 percent (MPCA, 2006). For all surface waters in the state, MPCA estimates that 26.4 percent of the total P delivered are attributed to surface runoff from cropland and pastureland during average flow conditions. Agricultural tile drainage, feedlots, and atmospheric deposition accounted for 1.8, 1.0, and 13.1% of the total P contributions during the average flow years, respectively. Furthermore, the study attributes 4.8 percent of the total P in the statewide surface waters to urban runoff during average flow years (Barr Engineering, 2004).

Farm Scale Study

A farm survey conducted in Seven Mile Creek Watershed in 2002 serves as an example of phosphorus use in the basin. Eighteen farms were interviewed totaling 11,000 acres of farmland. The cropland was dominated by a field corn and soybean rotation (93% of all acres). Commercial Phosphorus (P) applications accounted for 75 percent of the total P applied for corn acres with the balance of P contributed from manure (mostly hog). Average commercial fertilizer rate of phosphate across all field corn acres was 36 pounds per acre. A total of 263,000 pounds of P were applied on inventoried fields (MDA 2002).

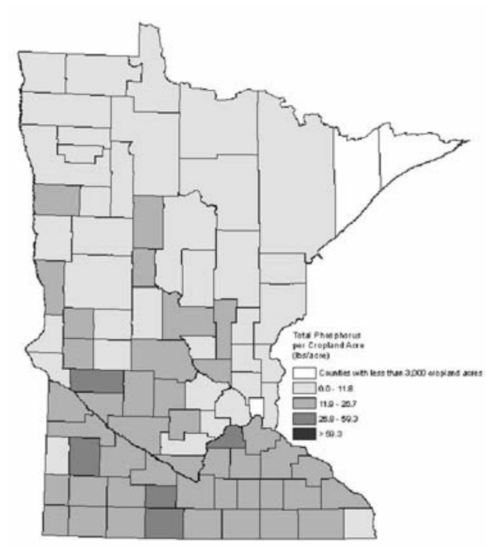
Destination of commercial phosphate used on field corn acres

- 84% Field Corn
- 12% Sweet Corn
- 4% Alfalfa

Pat Baskfield

Watonwan River diatom bloom (2007)

Phosphorus Applied



The map above depicts phosphorus input estimates based on 2002 Census data for county fertilizer sales and "fertilizer replacement" values from manure contributions. Inputs are averaged across all cropland acres within each county (Birr et al, 2008). The Minnesota River Basin stands out as a region with higher phosphorus inputs.

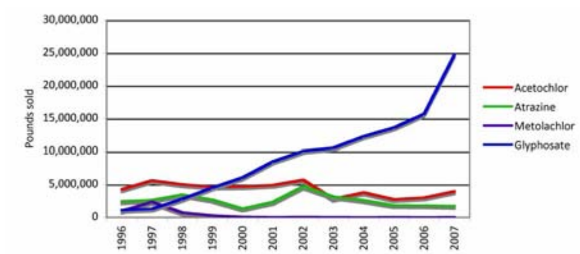
Pesticides

Pesticides

The Minnesota Department of Agriculture (MDA) is the lead state agency for most aspects of pesticide and fertilizer environmental and regulatory functions. The MDA publishes an annual pesticide sales data for pesticide active ingredients and data are currently available from 1996 to the present (http://www.mda.state.mn.us/chemicals/pesticides/pesticideuse.html).

Pesticide Sales in Minnesota 1996-2007

Pounds of pesticides sold

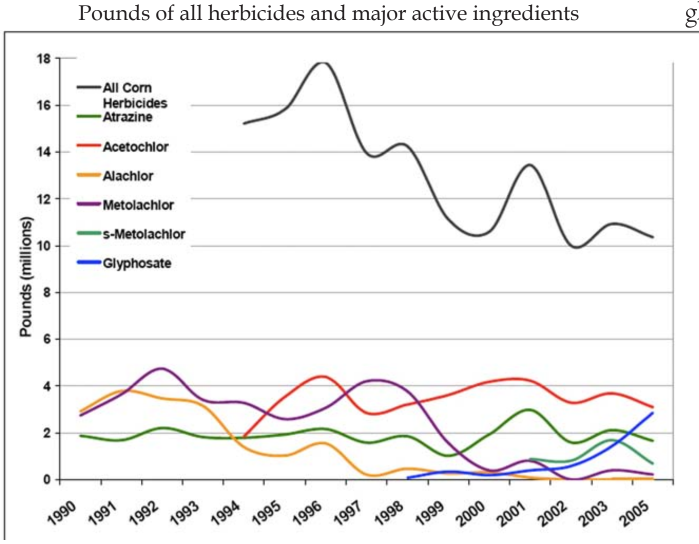


Source: MDA, Pesticide Sales Data. 2009.

The pesticides sales in Minnesota graph above illustrates the general decline in sales of metolachlor, atrazine, and acetochlor and significant rise in glyphosate sales from 1996 to the present. MDA notes that sales data provide an indication of long term pesticide use trends.

Total Corn Herbicide Use Estimates in Minnesota 1990-2005

Pounds of all herbicides and major active ingredients



Source: MDA, 2008

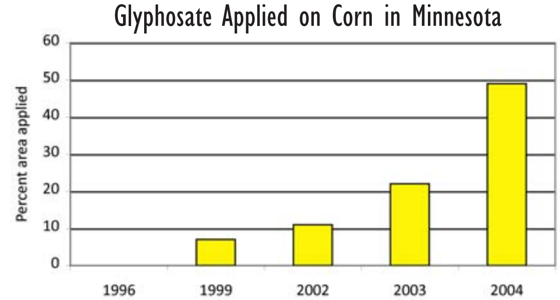
The graph above suggests an overall decline in pesticide usage on corn. With the increased use of the herbicide glyphosate on corn (shown in blue line) there has been a general decrease in the use of historically popular corn herbicides such as atrazine and acetochlor (MDA, 2008).

Rise of Glyphosate Tolerant Crops and Glyphosate

A significant trend in the past decade is the increase in the amount of glyphosate being applied on Minnesota corn and soybean acres across the Minnesota River Basin. The active ingredient glyphosate is a broad-spectrum herbicide marketed under several brand names, the most common being Roundup. Farmers apply glyphosate as a post-emergence herbicide against most broadleaf and grassy weeds. Roundup is produced by Monsanto who also produces Roundup Ready seeds that grow into plants genetically engineered to be tolerant to glyphosate. The genes contained in these seeds are patented.

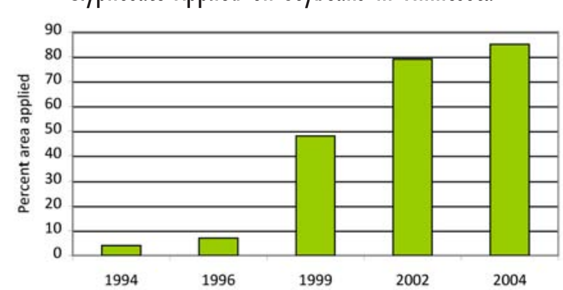
In 1996, genetically modified soybeans tolerant to glyphosate became commercially available, followed by glyphosate tolerant corn 1998. The graphs (below) show the rise in the use of glyphosate on both corn and soybean acres in Minnesota over the past decade. Virtually all (approximately 98%) of acres planted with glyphosate tolerant soybeans are treated with glyphosate. Approximately 85 percnt of acres of glyphosate tolerant corn are treated with glyphosate (Gunsolus, 2009).

Glyphosate Applied on Corn in Minnesota



Source: Gunsolus, 2009

Glyphosate Applied on Soybeans in Minnesota



Source: Gunsolus, 2009

A University of Minnesota agronomist estimates that by 2008, approximately 85 percent or more of the corn acres planted in Minnesota are glyphosate tolerant and 95 percent of the soybean acres are glyphosate tolerant (Gunsolus, 2009).

Pesticides continued

Commonly Used Pesticides (Analytes)	Pesticide Type	Trade Name Examples
Acetochlor	Herbicide	Surpass, Harness
Atrazine	Herbicide	Atrazine, Aatrex
s-Metolachlor	Herbicide	Dual, Brawl
Glyphosate	Herbicide	Roundup, Rodeo

Minnesota Department of Agriculture

Farm Pesticide Use Studies

To better understand pesticide use in Minnesota, the MDA conducts surveys designed to understand existing farm practices regarding agricultural inputs such as fertilizers, manures and pesticides. The surveys find that corn and soybean acreage accounts for the majority of pesticide application statewide. Pesticides are applied to over 95 percent of the major crops in surveyed areas. For more information about the studies, see the MDA website: http://www.mda.state.mn.us/appd/pesticides/pesticideuse.htm

Pesticide Use on Four Major Crops in Minnesota

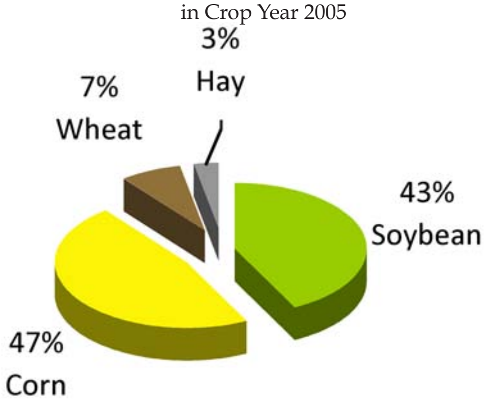
Minnesota Department of Agriculture performed a study of Pesticide Usage on Four Major Crops in Minnesota (Corn, Soybeans, Wheat and Hay) in 2005. Collectively these crops account for over 90 percent of Minnesota's cropland. Survey results from Pesticide Monitoring Region (PMR) 6 provides a case study for the Minnesota River Basin. PMR 6 lies entirely within the Minnesota River Basin and includes the following counties: Big Stone, Chippewa, Lac qui Parle, Stevens, Swift, and Yellow Medicine (see map below) (MDA, 2007).

Pesticide Use Study

Source: MDA, 2007

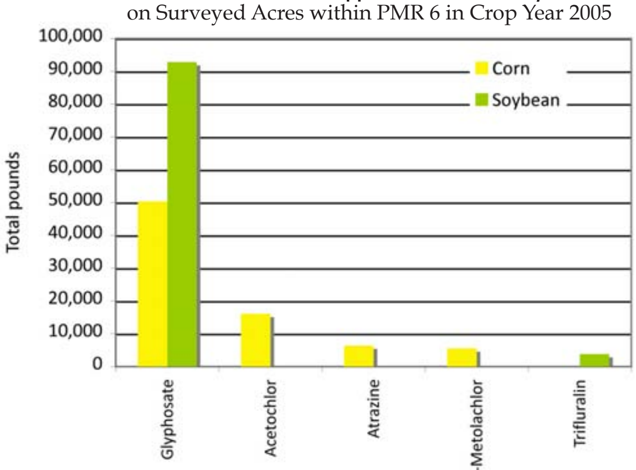
Crop Type

Percent of Acres Surveyed in PMR 6 in Crop Year 2005



Pounds of Pesticides Applied to Corn & Soybeans

on Surveyed Acres within PMR 6 in Crop Year 2005



The graphics at left and below show farm survey results for PMR 6. These results reflect the recent increase in use of glyphosate on both corn and soybean acres.

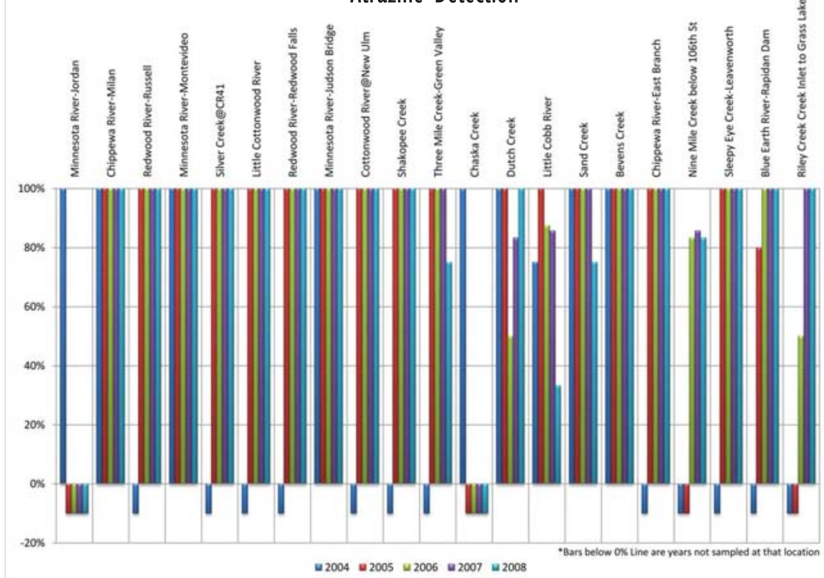
Corn Highlights (PMR 6): Herbicides, insecticides, and fungicides were applied to 97 percent, 18 percent, and 0 percent, respectively, of the surveyed corn acres. The top three herbicide products (based on percent acres covered) were glyphosate (48%), acetochlor (25%), and atrazine (24%).

Soybean Highlights (PMR 6): Herbicides, insecticides, and fungicides were applied to 98 percent, 44 percent, and 3 percent, respectively, on the surveyed acres of soybeans. Glyphosate products were applied to 89 percent of the acres. No other herbicides were applied on more than 4 percent of all soybean acres (MDA, 2007).

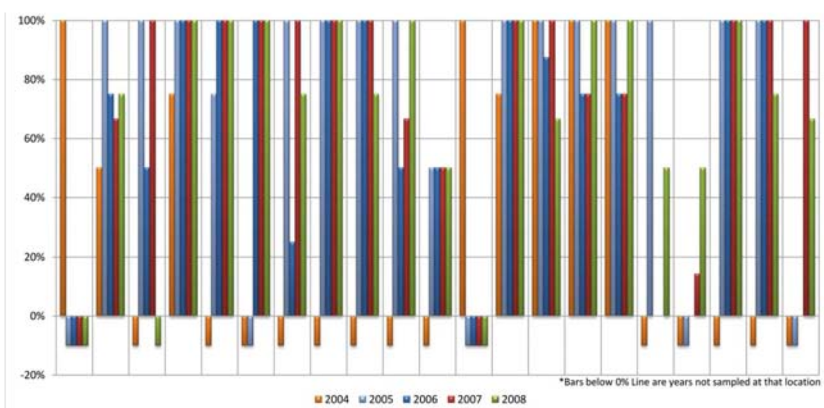
Pesticides Detected in Rivers and Streams

The MDA Monitoring and Assessment Unit collects water quality samples to evaluate pesticide detection patterns and to evaluate the presence of commonly used pesticides in the rivers and streams and groundwater across the state. In the Minnesota River Basin, the herbicides atrazine, metolachlor. and acetochlor, are the most frequently detected compounds in rivers and streams. The graphs below show percent detection for MDA pesticide monitoring sites within the basin from 2004-2008.

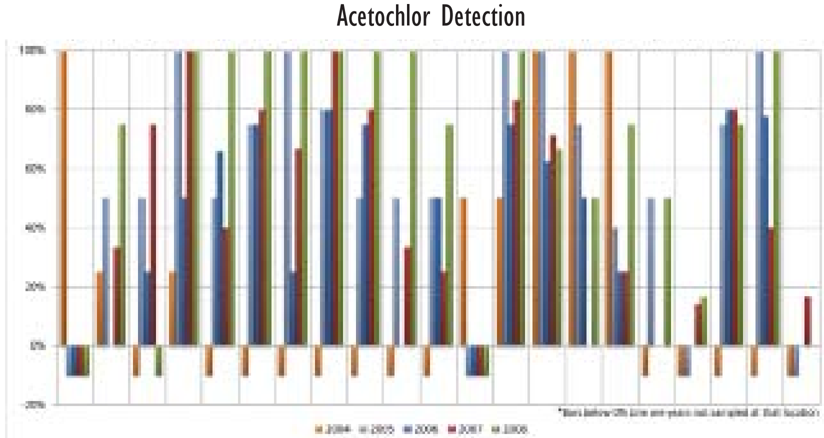
Atrazine Detection



Metolachlor Detection



Acetochlor Detection



Animal Agriculture

Hogs, cattle, and poultry industry in the basin

Minnesota Soybean

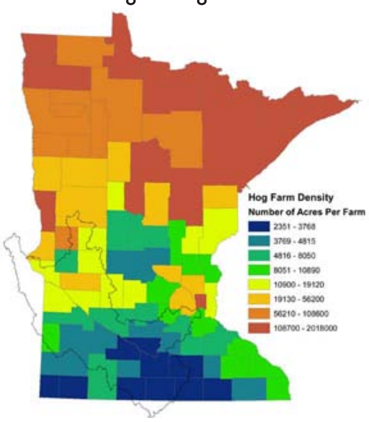
Rapid changes have taken place in animal agriculture in recent decades. Since the 1980's there has been increased concentration in production of dairy, swine, and poultry industry across the state and within the Minnesota River Basin. Livestock raising is a significant business in the Minnesota River Basin. There are approximately 10,000 feedlots in the basin. Registered feedlots contained about 2 million animal units in 2006 (MPCA, 2007). Roughly 5 percent of feedlots are larger than 1,000 animal units.

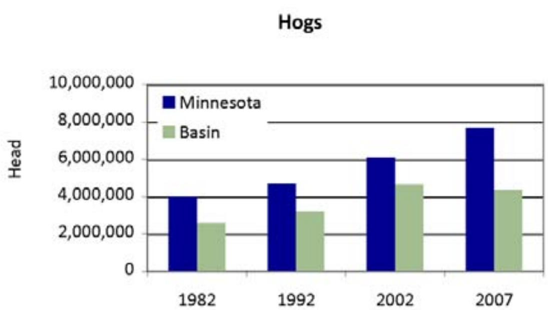
Hogs

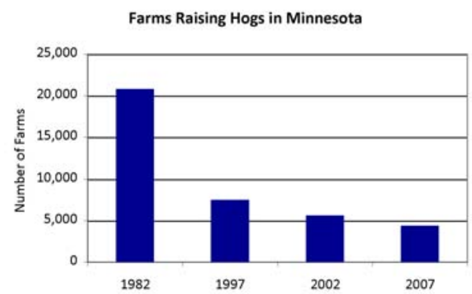
Minnesota Soybean

Minnesota is ranked third in the nation for production of hogs and pigs (approximately 7,500,000 produced in 2007). In Minnesota, the swine industry has traditionally relied on family farm production as part of a diversified farming strategy, but between 1982 and 2007, the number of farms raising hogs decreased dramatically while the number of hogs raised on Minnesota rose dramatically. In 1982, the average hog farm had 216 hogs while by 2007 the average rose to 1,757 hogs per farm.

Farms in Hogs & Pigs 2007

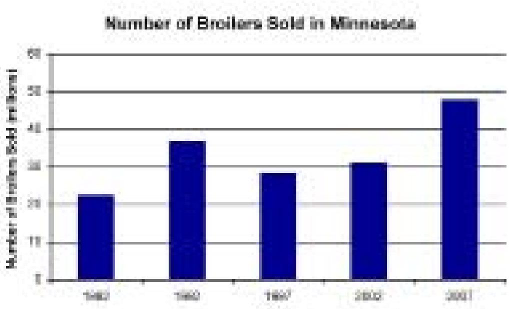






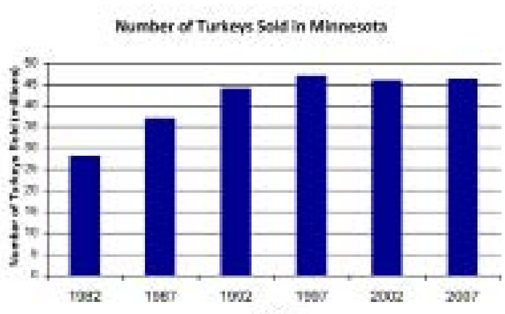
Poultry

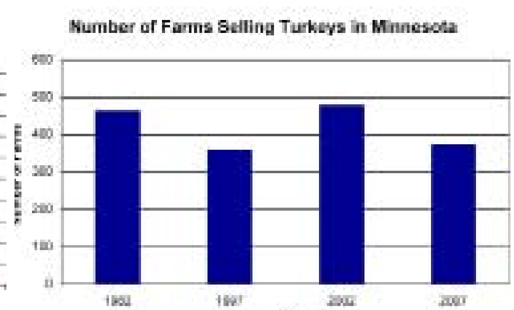
Minnesota is ranked first in the nation for turkey production (approximately 18,000,000 turkeys produced in 2007). The expansion of the poultry sector began in the 1950s in Minnesota and has continued into the present. From 1982 to 2007 the number of farms selling broilers and turkeys both decreased. The number of broilers sold increased significantly in 2007 while the number of turkeys sold maintained a more steady increase.



Minnesota Soybean

Minnesota Soybean



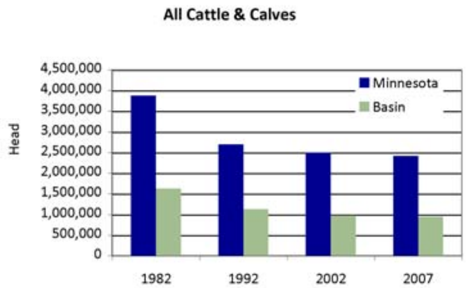


Animal agriculture continued


Minnesota Soybean

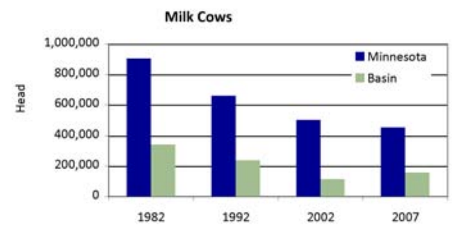
All Cattle and Calves

The total number of cattle and calves in Minnesota and in the basin have declined since 1980s.



Dairy

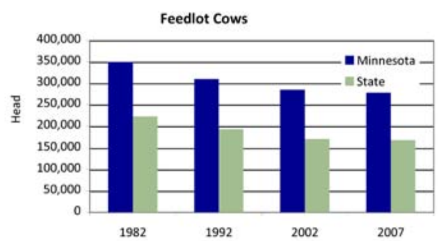
Between 1982 and 2007 the number of farms in Minnesota with dairy cattle steadily and rapidly declined. In 1982, there were 24,178 dairy farms with the average herd size of 20 cows. By 2007, there were only 5,148 dairy farms with the average herd size increased to 89 cows.

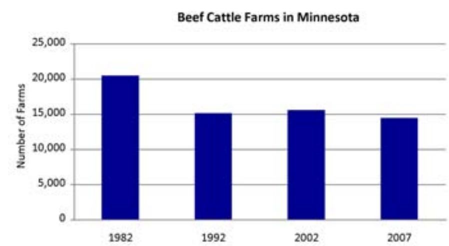


Beef

The number of beef cattle farms and herd size in Minnesota declined between 1982 and 2007 with only a small increase in average herd size (23 to 28 cows) over the time period.


Minnesota Beef Council

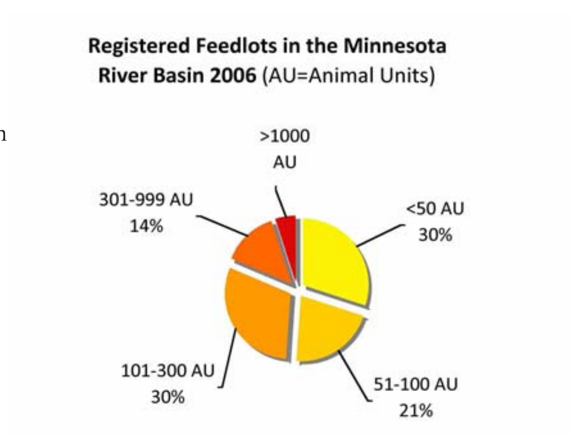




Feedlots and Manure Management

Manure management is increasingly important because of the larger livestock populations and increased concentration of production in the basin. More livestock per facility means more manure to manage. The Minnesota Pollution Control Agency (MPCA) is the principal agency for regulating feedlots in Minnesota. The MPCA, by law, may also delegate some of its feedlot program responsibilities to counties.

There are approximately 30,000 feedlots in Minnesota and approximately 30 percent lie within the Minnesota River Basin. In 2006, there were approximately 8,772 registered feedlots in the Minnesota River Basin (MPCA, 2007). Proper manure management is important to protecting ground and surface water. If manure is not handled properly it can be a source of bacteria, nutrients, ammonia and total suspended solids.



Land application of manure is the primary source of annual loading of feedlot-related nutrients to surface water (compared with manure spills and feedlot runoff) (Environmental Quality Board, 1999). Broadcasting manure onto a field is the oldest method of spreading. Another method involves broadcasting the manure and incorporating the manure into the soil within a few days. For liquid manure, injecting manure with chisel-type knife has become popular. Near waters, manure must be incorporated after application and generally will be applied over a greater number of acres to limit soil phosphorus build-up. This applies to any size feedlot (Montgomery, 2002).

Conservation Easements

Conservation Programs

Kevin Kuehner

There have been four major conservation easement programs dedicated to setting aside cropland in sensitive areas to protect and improve water quality. Three of the programs have involved the Federal Government including the Soil Bank program of 1950s and 1960s. Each of the programs has been designed to pay landowners a payment to plant some type of vegetative cover to keep soil on the land. Some of the programs permanently protect the land and others temporary take it out of crop production for a specific time period. All of these are voluntary programs.

1700-1860s
First Europeans explore the Minnesota River and describe a landscape dominated by prairie intermixed with wetlands, shallow lakes, and forested areas on the river floodplain.

1850s
Surveyor's record a landscape covered with wet prairie and wetlands.

1956-1960
Soil Bank Program pays farmers to retire land from agricultural production for up to ten years.

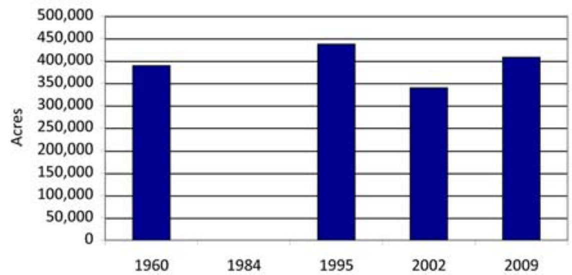
1973-1981
Secretary of Agriculture Earl Butz pushes farmers to plow up more land and expand their operation.

1985
Farm Bill creates Conservation Reserve Program (CRP).

1986
Minnesota develops the Reinvest in Minnesota Program (RIM).

1998-2002
Minnesota River Conservation Reserve Enhancement Program (CREP) enrolls over 100,000 acres of permanent easements.

Conservation Easements in the Minnesota River Basin



Permanent and temporary easements in the basin.

Soil Bank Program

In 1956, the U.S. Congress enacted the Soil Bank Program to divert land regularly used for crop production to conservation uses. Over the next four years farmers enrolled almost 29 million acres into a protective cover crop. Farmers could sign up for 5 to 10 year contracts. Most of the contracts for this program expired in 1969.

Conservation Reserve Program (CRP)

Offered through the U.S. Department of Agriculture (USDA), the Conservation Reserve Program (CRP) offers 10 to 15 year contracts to protect highly erodible cropland or other environmental sensitive acres by planting a vegetative cover including native grasses and trees.

Reinvest in Minnesota Reserve (RIM)

As one of the first of its kind programs in the U.S., Reinvest in Minnesota Reserve (RIM) pays landowners a percentage of the assessed value of their land to enroll it into a conservation easement to protect and improve water quality by restoring wetlands and planting native grass and/or trees.

Conservation Reserve Enhancement Program (CREP)

To assist in the restoration and protection of the MN River, the Conservation Reserve Enhancement Program (CREP) brought together federal and state funds to pay for permanent easements on critically sensitive cropland. Over 100,000 acres were enrolled in four years.

Scott Kudelka

One of the things we've seen along the river that was not obvious 10 years ago is the abundance of land along the river in the Conservation Reserve Enhancement Program. Today, these acres are visible all along the river, as tall willows and grasses cover land that was once farmed near the river. There are still crops hard against the river bank in places and the occasional cow pasture along the banks, but the farming up close to the river is much less evident than a decade ago. The benefit of returning land to vegetation was evident at a spot near Granite Falls. A former farm field was now covered in vegetation and under several inches of water. Using a clarity checking tube we found the water flowing out of the wetland to be greater than the 60 centimeter maximum in the tube. When we paddled a few yards out to the main channel, that clarity reading dropped to 22 centimeters.

John Cross & Tim Krohn
Mankato Free Press Reporters
Reflecting on changes in the Minnesota River from 1998 to 2008

Best Management Practices (BMPs)

Best Management Practices


Scott Kudelka

A diverse selection of government agencies, watershed projects and nonprofit organizations offer technical assistance and cost-share for a wide variety of conservation practices to help improve water quality by holding both soil and nutrients on the landscape. One of these practices is conservation tillage, defined as any tillage and planting system that covers 30 percent or more of the soil surface with crop residue, after planting, to reduce soil erosion by water runoff. This includes the practices of No-till/strip-till, Ridge-till and Mulch-till.


USDA NRCS

Crop Residue

According to the Natural Resource Conservation Service (NRCS), crop residue left on the surface shields the soil from rain and wind until emerging plants provide a protective canopy. Crop residue also improves soil tilth, adds organic matter to the soil, and may even result in a little grain being left for wildlife. Less tillage reduces soil compaction and saves the farmer time and fuel.

Conservation Tillage


Rice County SWCD

By adopting reduced-tillage methods, farmers help decrease the potential for erosion and loss of soil and phosphorus from cropfields. Recent University of Minnesota research in Scott and Le Sueur counties shows that adoption of reduced tillage is higher for larger farms. As a result, erosion is reduced because there is less soil disturbance. On the negative side, reduced tillage may bring about a greater reliance on chemical versus cultural and mechanical weed control methods, which tend to be more time consuming. Other recent field surveys indicated that the proportion of cropland under reduced tillage is increasing rapidly in the Minnesota River Basin, from single-digit percentages in the early 1990s (1992 NRI data) to 29 percent in 1995 and 42 percent in 1996 (MPCA, 1997).


Stearns County SWCD

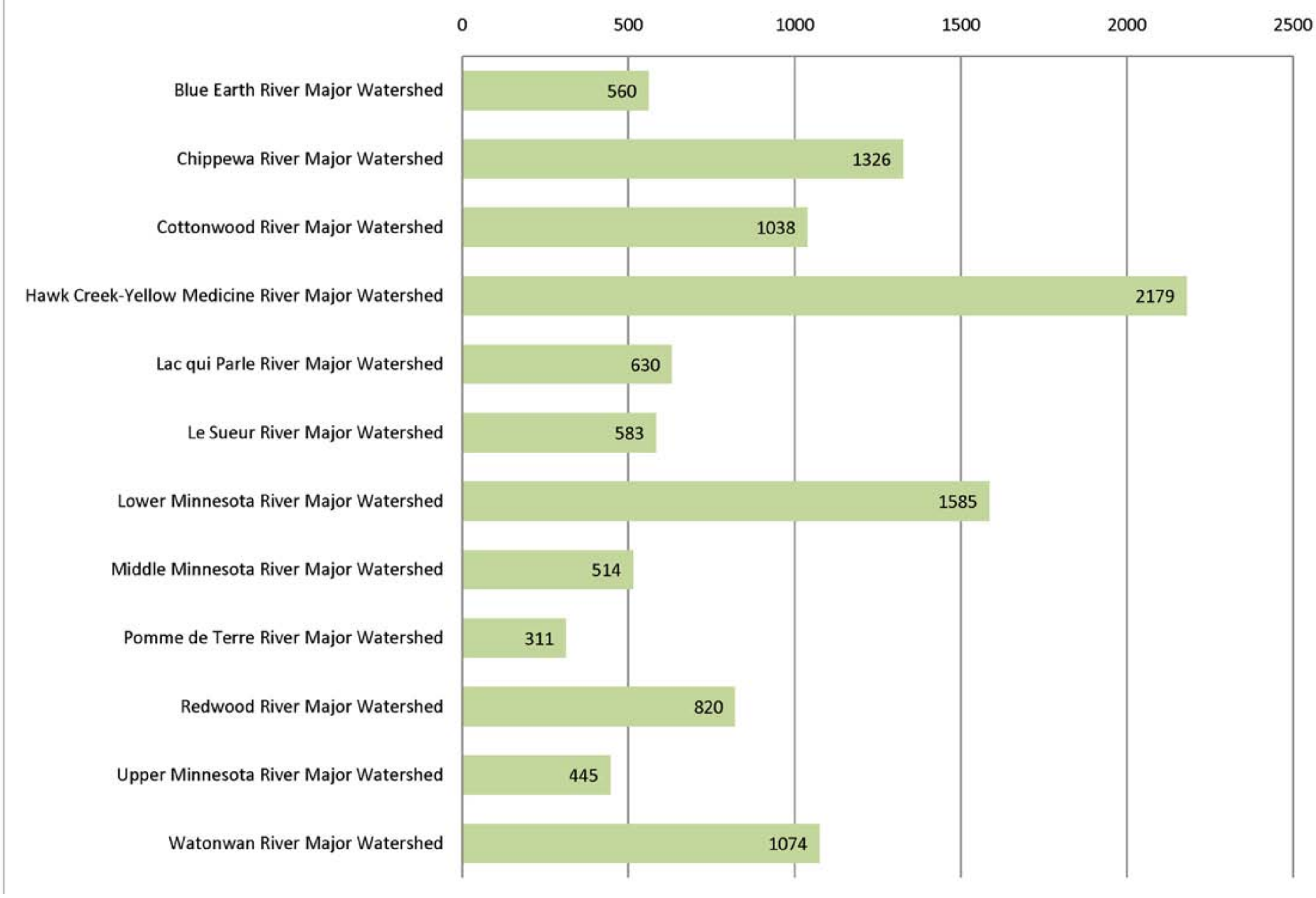
Tillage Transect Surveys

This is an annual survey of cropland to determine the soil erosion rate used to compile statistically accurate data on soil erosion by randomly sampling cropfields (Vernon, WI Soil and Water Conservation District office). Tillage Transect Surveys have been conducted across Minnesota on a fairly regular basis since 1989. A number of organizations have led this effort including NRCS, Minnesota River Board and Minnesota Board of Water and Soil Resources (BWSR).

In 2008, the Water Resources Center at Minnesota State University, Mankato compiled the data from all the surveys in a report to BWSR. According to this report, conservation tillage practices on cropfields have been increasing since the surveys were first conducted in 1989. The report stated, "Soybeans in Minnesota, for many practical reasons, appeared to be a driving force in residue management improvements. Conservation tillage shifted from 20.2 percent of soybean acres in 1989 to 56.6 percent in 2007." On the other hand, residue on corn ground peaked in 1993 at only 27.2 percent.

Additional BMPs are being utilized and implemented across the Minnesota River Basin including filter strips, wetland restoration, grass waterways, shelter belts, riparian buffers, nutrient management, field wind breaks, living snow fences, streambank restoration and structures like water and sediment control basins, grade control structures and alternative tile inlets.

Best Management Practices per Major Watershed in the Minnesota River Basin



The chart above illustrates the Best Management Practices (BMP) recorded in the Minnesota River Basin from 1997-2008. The data is from the Board of Water and Soil Resources (BWSR) LARS (Local Government Annual Reporting System) 1997-2002 and e-Link reporting system (2003-2008). The number of BMP's in the chart reflect only the actual contract for that BMP and not the acres contained in that BMP.

Best Management Practices Timeline

1928: Dr. Hugh H. Bennett publishes the now classic, 1,000-page book titled "Soil Conservation." Today, it is widely recognized as the "menace" bulletin that sparked the modern soil conservation movement.

1930s: Soil conservation efforts go into crisis mode during the devastating decade-long drought that causes massive dust storms to blow across the Great Plains. The federal government creates numerous agencies and programs to tackle this intense problem.

1940s: By the start of World War II, the Soil Conservation Service (SCS) leads the effort to install soil conservation practices under the U.S. Department of Agriculture along with Soil and Water Conservation Districts (SWCD) on the local level.

1950s & 1960s: In 1965 there are 89 SWCD's organized in the state. Over these two decades, SWCDs go from demonstrating conservation practices to providing planning and engineering assistance. One of the major programs of this time period is the Soil Bank Program, setting aside cropland from production in a ten-year easement.

1960s to 1985: SWCDs began to promote crop residue management / conservation tillage as an erosion control measure. In 1976, the State Cost-share Program is put in place to help pay for conservation practices.

1985: New Farm Bill creates the Conservation Reserve Program (CRP), conservation compliance along with the swampbuster and sodbuster provisions.

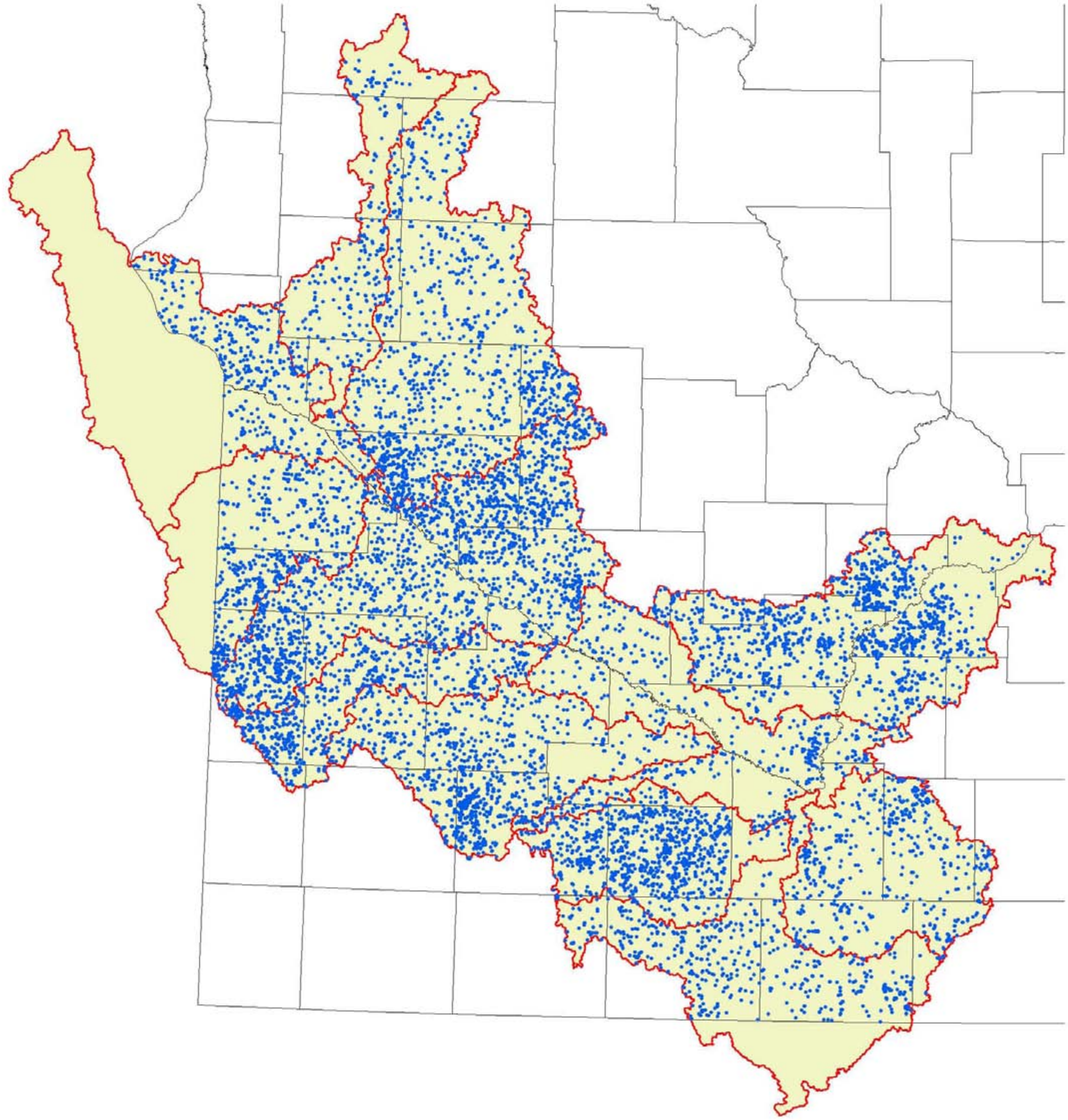
1980s to 1990s: Reinvest in Minnesota Program (RIM) is launched in 1986 to help protect critically sensitive lands and a year later the Board of Water and Soil Resources (BWSR) forms from three separate agencies.

Today: Ninety-one SWCDs operate across Minnesota working with government agencies on the local, state and national levels, along with watershed projects and citizen groups to promote and install best management practices.

"Through these eyes: The First 70 Years of Soil and Water Conservation in Minnesota" by Vic Ruhland; Minnesota Office, USDA, Natural Resources Conservation Service.

Best Management Practices in the Minnesota River Basin

Based on BWSR's e-Link and LARS databases 1997-2008



The map above illustrates the Best Management Practices (BMP) recorded in the Minnesota River Basin from 1997-2008. The data is from the Board of Water and Soil Resources (BWSR) LARS (Local Government Annual Reporting System) 1997-2002 and e-Link reporting system (2003-2008). Please note that the data was mapped based on location and only indicates the point location of the BMP and does not reflect the acres contained in that BMP. The map illustrates the differences in density of BMPs among major watersheds.

Wastewater

Significant Phosphorus reduction

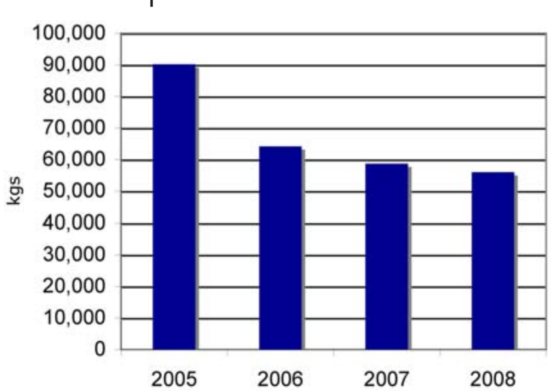
Municipal Wastewater Treatment

There are 152 permitted municipal and industrial wastewater treatment facilities in the basin. Phosphorus from these facilities is a particular concern because it is the nutrient primarily responsible for the eutrophication of Minnesota's surface waters. Eutrophication is a process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that can stimulate excessive plant growth. This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms to die.

Hundreds of millions of dollars have been invested to upgrade wastewater treatment plants across the basin. In 2005, Minnesota developed a Phosphorus General Permit to reduce phosphorus discharged by point sources into the Minnesota River Basin. Forty-seven of the 152 facilities are required to reduce phosphorus as part of this General Permit. Under the permit, the point sources have the option of trading to meet their water quality-based effluent limits. Trading also allows new or expanding dischargers of phosphorus the opportunity to purchase phosphorus loads from others to offset their new or increased phosphorus load. Seventeen trades occurred in 2008 under the permit.

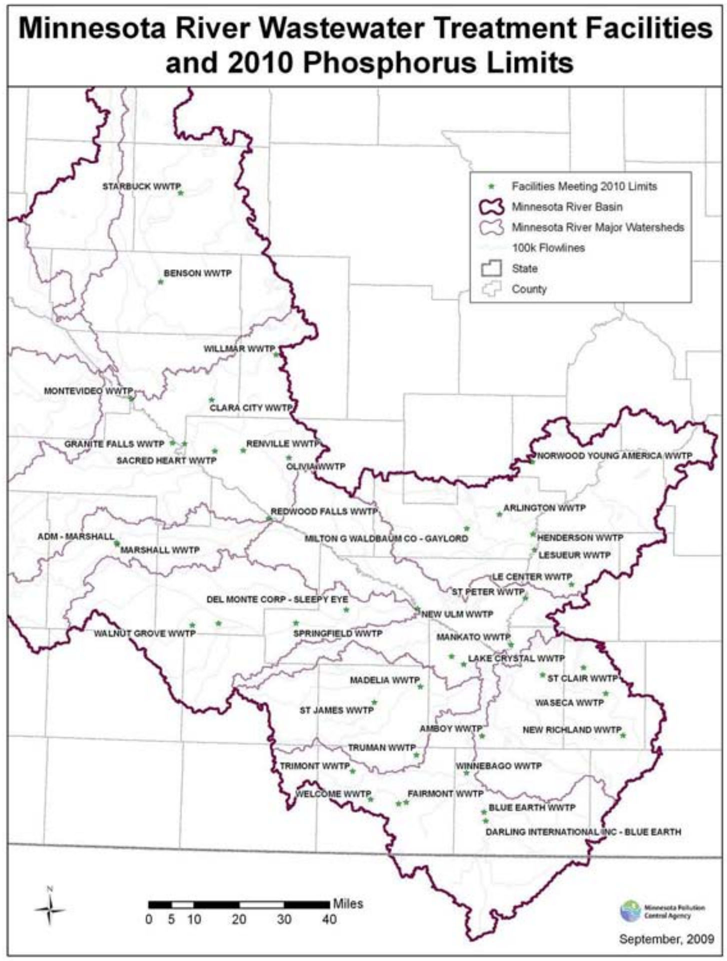
The Phosphorus General Permit sets effluent limits in stages: 15 percent by 2008, 25 percent by 2009, 35 percent by 2010 and 50 percent by 2015. As of Summer 2009, collectively the 47 facilities are meeting their 2010 limits (see map at right). Twenty-four facilities are at or below their individual 2010 goal. Three more were upgraded in 2008 and should be in line by the end of this season.

Phosphorus Reductions 2005-2008



The chart above shows the reduction in the amount of phosphorus being discharged into the Minnesota River due to wastewater treatment plant upgrades.

Wastewater Treatment Plants have already met the 2010 state goal of 35 percent reduction in the amount of phosphorus plants carry into the Minnesota River.



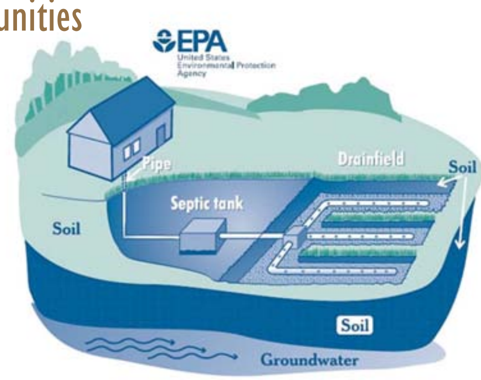
Minnesota River Phosphorus Reductions—Highlighted as an EPA Success Story

"The Metropolitan Council owns and operates eight municipal wastewater treatment plants in the Twin Cities metropolitan area of St. Paul and Minneapolis. Since 1990, the Council has achieved dramatic reduction in phosphorus discharged from its plants to area receiving waters. Since the peak of phosphorus discharge in 1995, the Council has achieved a 78 percent reduction in phosphorus loads.

To understand the magnitude of such a reduction, it would be as if we went back to before 1900. At that time, the metropolitan area had a population of 500,000 people and an estimated 1,860 pounds per day of phosphorus was discharged to area rivers. Today, two million more people live in this area, yet discharge only 1,670 pounds per day" (EPA, 2009).

Septic Systems & Undersewered Communities

Significant progress addressing undersewered incorporated communities



Compliant Private Systems

There are many effective private septic systems across the basin. Septic systems consist of a septic tank connected to a drainfield (see diagram at right) and are an effective means for treating wastewater. When properly sited, installed, and maintained individual septic systems remove most of the bacteria and viruses in the wastewater within two to three feet below the drainfield. Individual sewage treatment systems are regulated by local governments in Minnesota, primarily counties, although cities and towns may also choose to regulate the systems (BID, 1997).

Non-compliant Private Sewage Systems

Surveys conducted in southern Minnesota show that many systems lack the soil treatment system component (the drainfield) of the septic system, and wastewater from the septic tank is allowed to flow into tile drains or drainage ditches. In these situations the effluent, which contains solids, bacteria, viruses, and organic materials, enters the surface water without being treated by the soil treatment system. Surface discharges of sewage can present health problems due to pathogens that may be present. Additionally, a septic system that fails to fully treat sewage allows excess nutrients (phosphorus and nitrogen) to reach nearby lakes and streams, promoting algae and plant growth. Algal blooms and abundant weeds may make lakes and rivers unpleasant for swimming, boating, and other water-based activities.

Counties submit yearly annual reports to the MPCA, which include local estimates of imminent public health threat septic systems (see chart below). These estimates also include systems that are not Imminent Threats, but are classified as Failing to Protect Groundwater. All systems and small communities classified as Imminent Threats to Public Health and Safety are illegal under Minnesota rules (MPCA, 2007).

	1990*	2004**	2008**
Estimated Total Number of Septic Tanks	67,630	79,722	77,155
Estimated Failing Systems	(No data)	27,710 (35%)	24,790 (32%)
Estimated Imminent Threat to Public Health or Safety (IPHT)*** (Discharge to surface)	30,000 (44%)	20,000 (25%)	17,279 (22%)

* Estimate based on 1990s work completed as part of the Minnesota River Assessment Project and included interviews in 37 minor watersheds within 9 major watersheds and may be conservative.
** Based on county reports to MPCA based on estimates in their record keeping. For 2008, Hennepin's 2007 data and Lyon's 2006 data were substituted due to a lack of data.
***Imminent threat to public health or safety (IPHT) means situations with the potential to immediately and adversely affect or threaten public health or safety, including ground surface or surface water discharges and sewer back up into a dwelling or other establishment. IPHT are sometimes called straight pipe systems. Straight pipe systems include toilet waste and transports raw or partially settled sewage directly to a lake, stream, drainage system or ground surface.

Upgrades Make a Difference

Recent research in the Seven Mile Creek Watershed (Nicollet County) shows that replacing straight-pipe discharges with good septic systems does make a difference. Watershed staff documented the before-and-after impacts of one straight-pipe upgrade in reducing bacteria levels in the creek. In this study, a straight-pipe system was upgraded to a mound and bacteria concentrations from the pipe were reduced to near zero immediately.

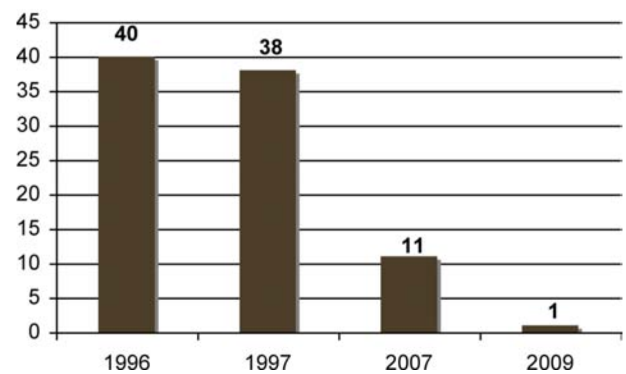
Before: Monitoring shows that average E. coli bacteria levels from the suspected tile line were three times higher than EPA's proposed water quality standards for streams like Seven Mile Creek. Number of samples exceeding standard: 72%

After the Upgrade: E. coli bacteria reductions from the suspected drainage tile were immediate. Overall, the septic upgrade reduced drainage tile water E. coli concentrations by 98 percent. Number of samples exceeding standard: 0% (Kuehner & Matteson, 2006).

Undersewered Communities & Unincorporated Areas

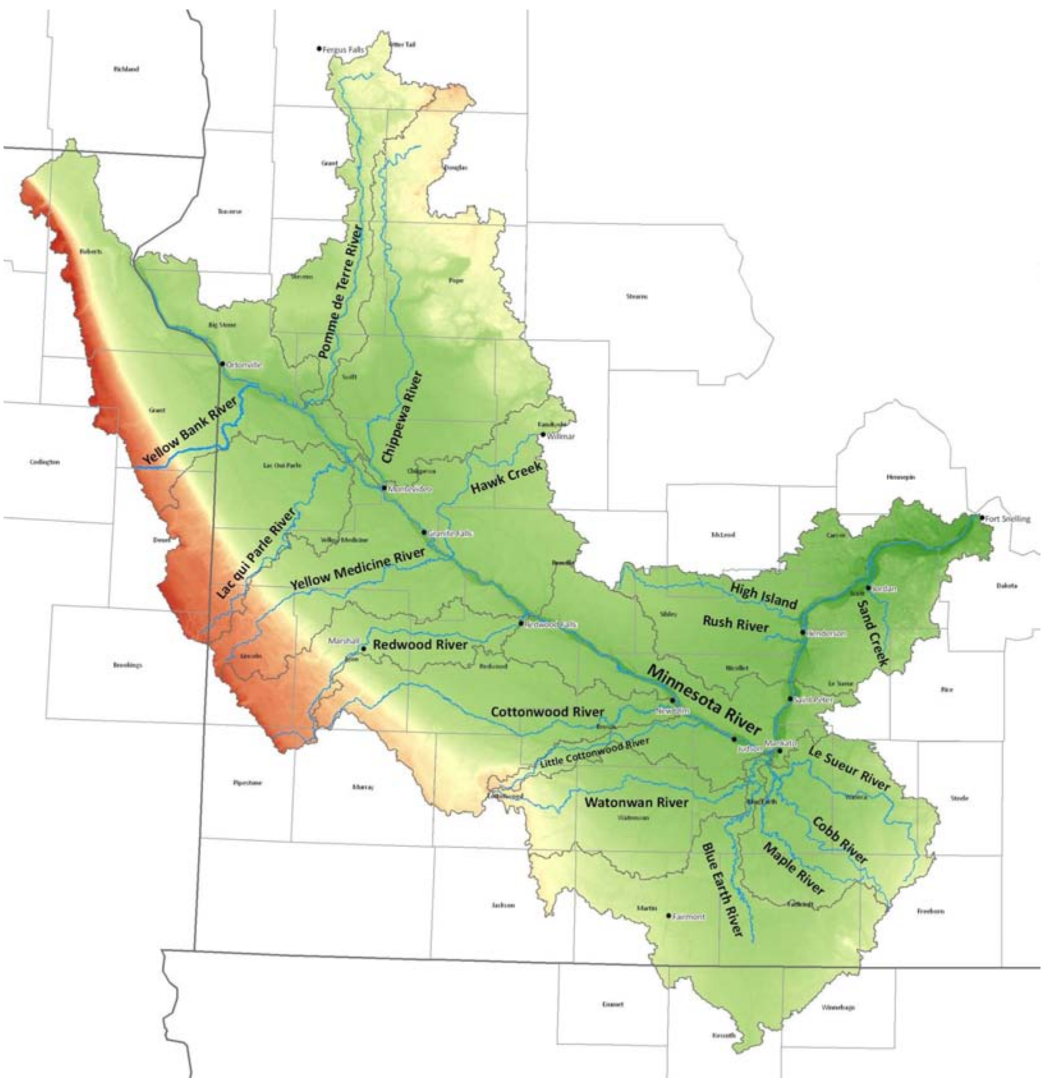
Across the basin, there are also small incorporated communities that are undersewered. Local governments have been fixing this problem by installing their own systems or sharing it with a neighboring community. Significant progress in this area is shown as 39 communities in the basin have addressed the problem since 1996. By 2009, only one facility remains to be addressed (Heidelburg). A goal of the MPCA is to have all wastewater in Minnesota adequately treated by 2011. Undersewered small unincorporated areas are another source of pollution. Although there is no basin-wide sampling data for these areas, the MPCA continues efforts to see that these areas and remaining undersewered communities treat their wastewater. Here's link to learn more about small community wastewater needs: http://www.pca.state.mn.us/publications/wq-wwtp1-06.pdf

Undersewered Incorporated Communities in the Minnesota River Basin



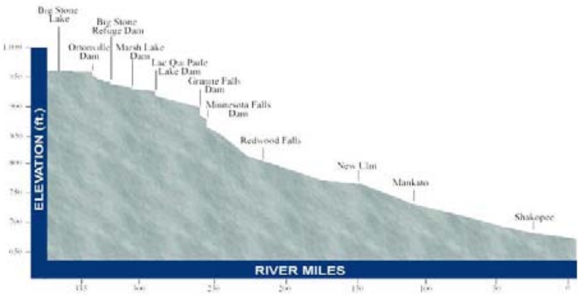
Rivers & Streams

The Minnesota River drains a basin of 14,840 square miles including all or parts of 37 counties; 1,610 square miles in South Dakota and the remaining area in North Dakota and Iowa. The Minnesota River meanders 335 miles from where it originates on the Minnesota-South Dakota boarder to its confluence with the Mississippi River near Fort Snelling. Surface water flow to the river comes from 1,208 minor watersheds. The Minnesota River Basin is divided into 12 hydrologic major watersheds and 13 management watersheds. The following section provides an overview of water quality trends in the basin. More detailed information about surface water quality monitoring can be found in the State of the Minnesota River reports:
http://mrbdc.mnsu.edu/mnbasin/state/index.html



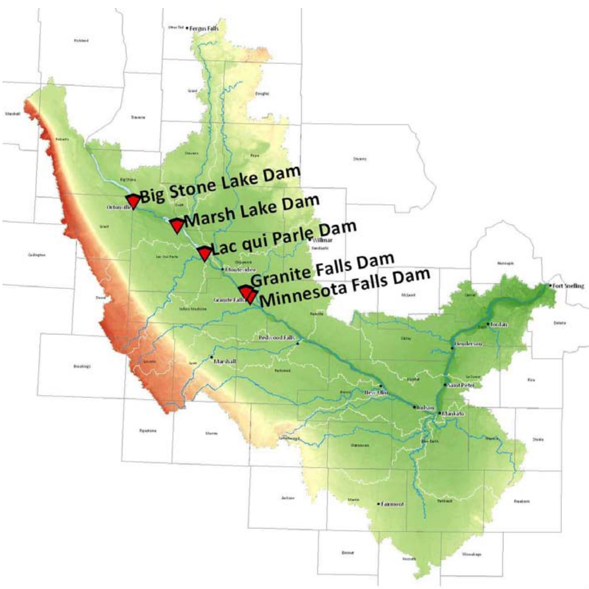
On September 22, 1992, Governor Arne Carlson stood on the banks of the Minnesota River in Bloomington while holding a jar of dirty water and declared it was time to clean up this waterway. "Our goal is that within 10 years, our children will be swimming, fishing, picnicking and recreating at this river," Governor Carlson stated. After years of neglect, citizens, government agencies and nonprofit groups began to focus on restoring, improving and protecting the Minnesota River. In the span of a decade the river was listed as one of the most Endangered Rivers in the nation, the focus of a watershed-wide study – Minnesota River Assessment Project and saw the enrollment of over 100,000 critically sensitive acres into permanent easements.

River Profile



The Minnesota River falls 274 feet from its headwaters at Big Stone Lake (964 feet) to the confluence with the Mississippi (690 feet). It drops approximately 0.8 feet per mile.

Dams on the Minnesota River



There are five major dams on the Minnesota River. Dams have been constructed at the outlets of Big Stone Lake, Marsh Lake, and Lac qui Parle to control lake levels and floodwaters. These dams create extensive lakes which are important wildlife management areas and hunting grounds. The other two dams are located in Granite Falls and a few miles downstream from Granite Falls called Minnesota Falls Dam.

Scott Kudelka

Granite Falls dam

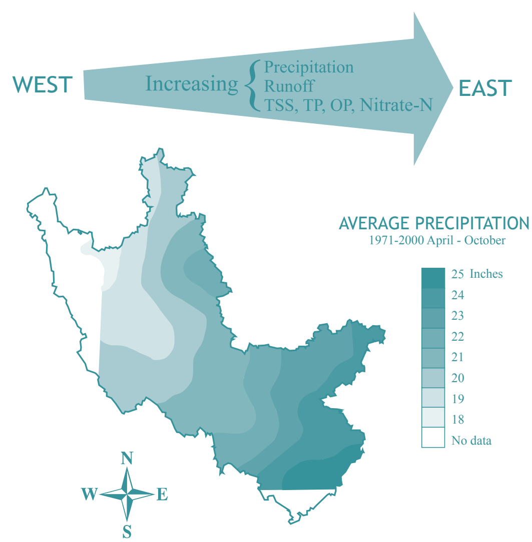
Climate Change & Precipitation

In the 1930s, many parts of the United States including Minnesota suffered through one of the driest periods in recorded history. Beginning around 1936, the average rainfall amount in Minnesota has steadily increased along with some extreme wet and dry years. According to the Minnesota Pollution Control Agency, precipitation in some areas of the state has increased by up to 20 percent, especially in the southern half.

Minnesota's location in the middle of the continent results in a variable climate due to the variety of air masses that flow across the state. Winters are typically dominated by cold, dry continental polar air and also occasionally replaced by somewhat milder maritime polar air (State Climatology Office, 2004). During the summer, Minnesota usually sees a clash between hot and dry continental tropical air masses from the desert southwest and the moist maritime tropical air coming up from the Gulf of Mexico.

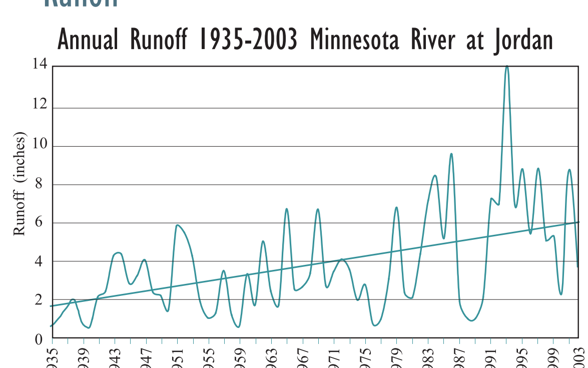
Precipitation is projected to increase by around 15 percent in the winter, summer and fall, with little change during the spring season according to MPCA. This state agency also projects a likely increase in the number of heavy rainfall events during the summer and the frequency of extremely hot days.

Precipitation



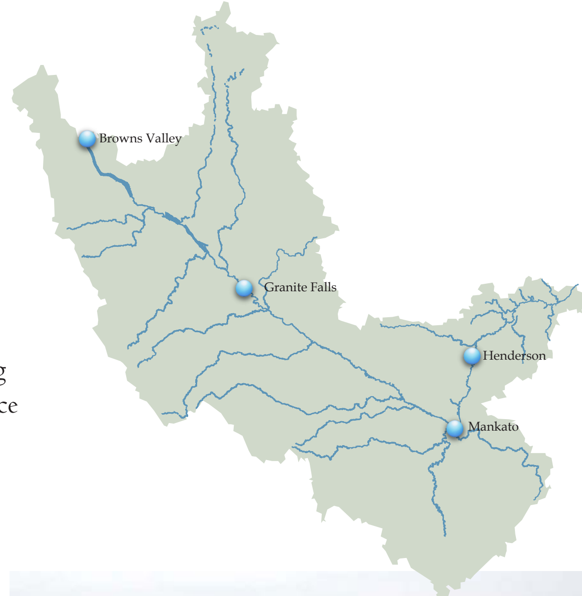
The Average Precipitation 1971-2000 map illustrates the west-to-east precipitation and runoff gradient. There is more rainfall as one moves eastwardly across the basin. Yields of key water quality pollutants (TSS, TP, OP and nitrate-N) follow this same general pattern of increasing in an easterly pattern.

Runoff



The annual runoff 1935-2003 graph illustrates the trend of increasing runoff volume over the past several decades. There is highly variable runoff from one year to another.

Rivers & Streams: Flooding
A natural and "man-made" phenomenon



Flooding is a natural occurrence of a river's riparian zone and provides many benefits including groundwater recharge, settling out sediment and supporting valuable wildlife habitat. A flood occurs when a waterbody like the Minnesota River receives a greater volume of water than it can handle, either at spring snowmelt or during a heavy rainstorm. Flooding only becomes a concern to humans when they impact the river's floodplain either by adding structures or planting crops. Humans have added to flooding problems primarily by intruding on the natural floodplain, but also by increasing the amount of impervious surface on the terrain and by displacing other natural storage on the landscape.

Browns Valley

Situated on a convex alluvial fan of the Little Minnesota River that drops rapidly some 780 vertical feet as it flows out of the Coteau des Prairies, the city of Browns Valley has dealt with major flooding issues since it was established in 1866. Most recently on March 4, 2007, the town was overwhelmed by intense and disasterous flooding when rapidly melting snow and ice jams forced the evacuation of about 100 people. The Little Minnesota River alluvial fan has partially filled the Glacial River Warren spillway in which it is located to form a very unique and dynamic quasi Continental Divide between the Red River and the Minnesota River basins. The convex form of the still actively forming alluvial fan and subsequent continental divide may distribute discharge from the Little Minnesota River north, east and south as different times or at the same time depending on the amount of discharge and the distributary nature of the stream channel at a particular point in time.

JOR Engineering

"Mother nature and humans have unwittingly concocted one of the most complex flood situations ever imagined at Browns Valley."– Dave Craigmile

Dave Smiglewski

John Cross

Granite Falls

One of two cities with development on both sides of the Minnesota River, Granite Falls has been hit hard by flooding including 1997 (11.3 feet above flood stage) and 2001 (7.3 feet) with considerable damage to both residential and commercial buildings. To mitigate some of the flooding problems, the city has built a retaining wall and incorporated it with buildings located along the river, relocated other businesses and homes and put in additional flood prevention measures. In the near future, city officials hope to improve the levee, relocate City Hall and build a new water treatment plant out of the floodplain.

What Increases the Flooding Risk?

- Removal of stabilizing vegetation around stream banks and rivers
- Erecting structures that deflect or inhibit the flow of floodwaters
- Constructing bridges, culverts, buildings, and other structures that encroach on the floodplain.
- Drainage systems that funnel stormwater quickly into a receiving body of water like the MN River.
- Straightening meandering watercourses to hasten drainage.
- Filling and dumping of debris in floodplains.


Mankato Free Press


Mankato Free Press


Scott Kudelka

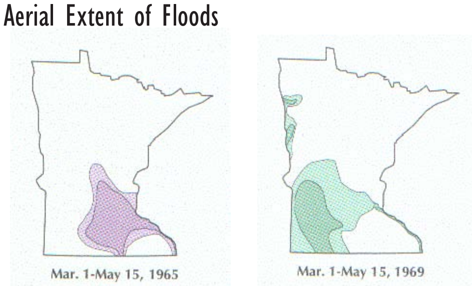
Mankato & North Mankato

Construction of a Flood Control System by the U.S. Corps of Engineers after the devastating 1965 flood has spared Mankato and North Mankato from any serious flooding since that time. Mankato is located at the confluence of the Blue Earth and Minnesota rivers. A doubling of water flow caused wide-spread flooding in 1881, 1908, 1916 and 1951 before the final major flood event in 1965. Today, both cities are protected by a flood wall levee system started in 1959 and finished thirty years later on each side of the Minnesota River along with sluice gates, additional gates and values, large pumps and pumping stations. Mankato and North Mankato have begun to make strides to make the Minnesota River a community asset.

Henderson

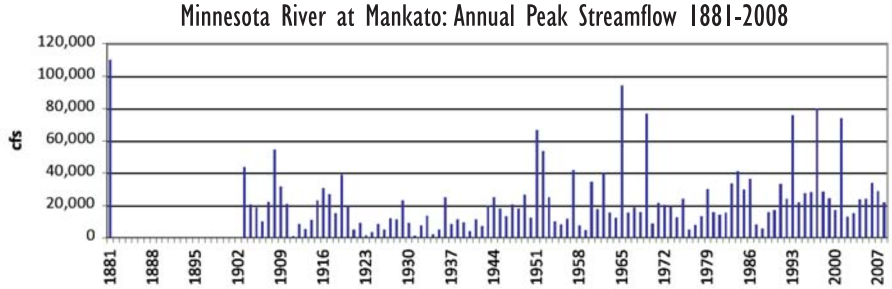
One of the historically significant towns along the Minnesota River, Henderson has been able to protect itself from flooding problems and still maintain some of its connection to the river. The 1965 flood hit this small community hard with a crest of 31.4 feet (highest in history). Approximately 285 people were evacuated from 95 homes. A $2.4 million levee system was completed by the U.S. Corps of Engineers in 1990 surrounding the city on three sides. This 1.5 mile permanent levee protected Henderson during the 1993, 1997, and 2001 floods along the Minnesota River. Today, residents enjoy a walking trail on top of the levee providing a close-up view of the Minnesota River floodplain.

Aerial Extent of Floods



Source: Minnesota Floods and Droughts

Minnesota River at Mankato: Annual Peak Streamflow 1881-2008



Source: USGS

Major Floods 1881-2009: Historical Crests at USGS Gaging Sites

	1881	1919	1951	1952	1965	1969	1986	1993	1997	1998	2001	2009
Savage			3	4	4	4	2	4	4		4	
Shakopee			3	3	4	3		3	3	2	3	
Jordan					4	3	2	3	3		3	
Henderson					4	3		4	3		3	
Mankato	3		2	2	3	3		4	3		3	
New Ulm						4			4	2	4	2
Granite Falls		3	2	3	2	4					3	
Montevideo		3	3	4	3	4	3	3			4	3

Source: USGS

4=Major Flood Stage
3=Moderate Flood Stage
2=Flood Stage

Rivers & Streams: Water Quality

Water Quality Monitoring

State and federal agencies have collected water quality data at various times in various locations throughout the Minnesota River Basin during the past thirty years. The most comprehensive study of water quality Minnesota River Basin, the Minnesota River Assessment Project, was conducted 1989-1994. The study concluded that the Minnesota River was impaired by excessive nutrient and sediment concentrations. Subsequent to those findings, considerable attention and support have been given to clean up efforts. Today, large portions of the Basin do not meet state water quality standards for bacteria, turbidity, dissolved oxygen, ammonia, and biota and are listed on Impaired Waters List (303(d) List). Learn more about Impaired waters on the MPCA website: http://www.pca.state.mn.us/water/tmdl/index.html).

– means decreasing trend/pollutant decreasing
+ means increasing trend/pollutant increasing
NT means no statistically significant trend
ID Insufficient data
mixed means trend tests vary

Pat Baskfield

Rapidan Dam on the Blue Earth River

Water Quality Trend Analysis

Since 2000, surface water quality data across the Basin has been collected and assembled in the State of the Minnesota River reports (produced every two years). These can be found on the Minnesota River Basin Data Center website: http://mrbdc.mnsu.edu. As the length of water quality records grew to a decade in many locations, there was sufficient data to run trend modeling programs to investigate if we can see any water quality trends in the Minnesota River mainstem, major tributary, and minor tributaries.

Minnesota State University, Mankato Water Resources Center recently completed a trend study headed by mathematics professor Deepak Sanjel and an interagency team. The study tested two trend models to examine water quality trends in the Minnesota River Basin: Seasonal Kendall trend model and the USGS Quality of Water trend program (QWTREND). Enough data was available to perform trend tests on 3 mainstem, 8 major tributary, and 4 minor tributary monitoring sites. Each monitoring site was analyzed for four primary water quality pollutants of concern: Total Suspended Sediment, Total Phosphorus, Nitrate-Nitrogen, and Orthophosphorus. A summary of results is presented in the table below. The study is available on the Minnesota River Basin Data Center website: http://mrbdc.mnsu.edu

	Total Suspended Solids	Total Phosphorus	OrthoPhosphorus	Nitrate-Nitrogen
Mainstem				
Judson	–	–	–	mixed
Mankato (SSC)	–	ID	ID	ID
St. Peter	–	mixed	–	NT
Major Tributaries				
Chippewa River	mixed	NT	–	NT
Hawk Creek	–	NT	NT	NT
Redwood River	–	NT	NT	mixed
Cottonwood River	–	NT	–	+
Watonwan River	–	–	–	–
Blue Earth	NT	–	–	–
Le Sueur	+	–	–	–
High Island	NT	NT	NT	NT

Comparison of Trend Studies

Percent overall change over time period indicated (Seasonal Kendall Trend Test)

Total Suspended Solids					
	Fort Snelling 1976-2001	Jordan 1976-2001*	Blue Earth 1967-2001	St. Peter 1971-2006	Judson 1998-2008
MPCA (Christopherson)	-40%	-31%	-49%	n/a	n/a
University of Minnesota (Johnson)	-48%	-39%	-52%	n/a	n/a
MSU,M Water Resources Center (Sanjel)	n/a	n/a	No Trend	-30%	-28%

Nitrate-Nitrogen					
	Fort Snelling 1976-2001	Jordan 1976-2001	Blue Earth 1974-2001	St. Peter 1971-2006	Judson 1998-2008
MCPA	No Trend	No Trend	No Trend	n/a	n/a
University of Minnesota	No Trend	-39% (76-01) -29% (76-02)	No Trend	n/a	n/a
MSU,M Water Resources Center	n/a	n/a	No Trend	-14%	+37

Total Phosphorus					
	Fort Snelling 1976-2001	Jordan 1976-2001	Blue Earth 1967-2001	St. Peter 1971-2006	Judson 1998-2008
MCPA	-35%	No Trend	-47%	n/a	n/a
University of Minnesota	-37%	-24% (76-01) -22% (76-02)	-52%	n/a	n/a
MSU,M Water Resources Center	n/a	n/a	-45% (99-08)	-30% (98-08) -47% (71-06)	No trend

* For the Jordan Site, For TSS MPCA analyzed 1976-2001 and U of M analyzed 1976-2002. For Nitrate-N and TP: MCPA 1979-2001, U of M 1979-2002

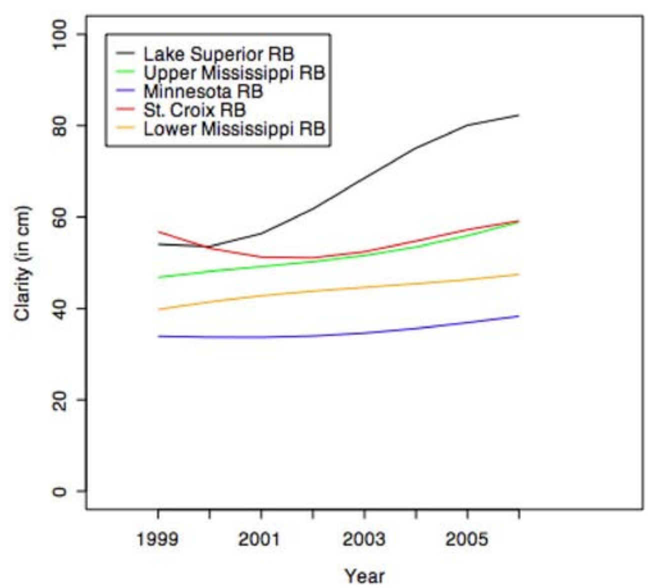
Pat Baskfield

Minnesota River Trend Studies have been performed by Minnesota Pollution Control Agency (Christopherson, 2002), University of Minnesota (Johnson, 2006), and Minnesota State University, Mankato Water Resources Center (Sanjel, 2009). The table at left illustrates that the trend studies all found reduction in TSS and TP in numerous mainstem sites during various time frames. For Nitrate-N, the studies indicated no trends or found mixed results. Taken together, these studies would suggest that at least some aspects of water quality in the mainstem of the Minnesota River have improved and continue to improve.

River Clarity Improving

Another statistical and graphical analysis was performed on data collected as part of Minnesota Pollution Control Agency's volunteer Citizen Stream Monitoring Program (CSMP). The study concluded that streams within the Minnesota River Basin (shown in blue below) had increasing water clarity over the study period 1999-2006 (Le, 2009).

Water Clarity Trends
Major River Basins of Minnesota



Minnesota River Basin Water Quality Links

State of the Minnesota River Reports
http://mrbdc.mnsu.edu/mnbasin/state/index.html

Environmental Data Access — Water Quality Data
http://www.pca.state.mn.us/data/eda/

DNR/MPCA Cooperative Stream Gaging
http://www.dnr.state.mn.us/waters/csg/index.html

MPCA Impaired Waters
http://www.pca.state.mn.us/water/tmdl/

Impaired Waters

More waters have been assessed and listed

Pat Baskfield

Blue Earth River and transparency tube

What are Impaired Waters?

A water body is considered impaired if the water quality in the stream or lake does not allow it to meet its designated use (such as swimming, fishing or for maintaining a healthy population of fish and other aquatic life). Water quality standards are set on a wide range of pollutants, including bacteria, nutrients, turbidity and mercury. A water body is "impaired" if it fails to meet one or more of Minnesota's water quality standards. The waterbody is then placed on the "303(d)" list, commonly known as the "impaired waters list." It is named after the section of the Clean Water Act in which the impaired waters law is found. Lakes, rivers and streams on the list are known to exceed water quality standards. Every two years, the Minnesota Pollution Control Agency (MPCA) releases the 303(d) list of impaired waters in Minnesota.

TMDL Program

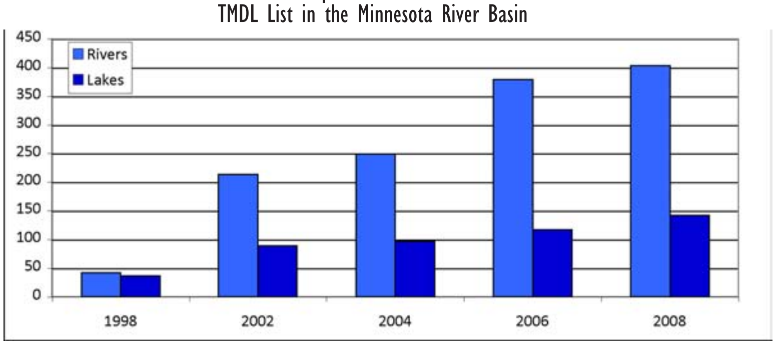
The process of dealing with "impaired waters" comes under the 303(d) Total Maximum Daily Load (TMDL) program. Each state is required to publish and update a list of "impaired waters" under Section 303(d) of the Clean Water Act. According to this act, a TMDL is a calculation of the maximum amount of pollutant from both point and non-point sources, that a waterbody can receive and still meet water quality standards. Once placed on the impaired waters list, the stream or lake needs a water quality improvement (TMDL) plan written.

Minnesota's Impaired Waters

The most recent list of Minnesota's TMDLs came out in 2008 with a total of 1,475 impairments on 336 rivers and 510 lakes. A significant decrease occurred between this latest list and the 2006 TMDL list, which recorded 2,250 impairments on 284 rivers and 1,013 lakes. The major reason for the dramatic change was the approval of the statewide Mercury TMDL by the U.S. Environmental Protection Agency (mercury impairments made up two-thirds of the 2004 TMDL list). A second part of the 2008 TMDL List is an Inventory of all impaired waters that contains a total of 2,575 impairments including the approved Statewide Mercury TMDL and Southeast Regional Fecal Coliform TMDL. According to MPCA, "waters in the Inventory of impaired waters will remain there until they meet water quality standards."

The Minnesota River Basin has 336 impaired waters on the 2008 TMDL list and 546 on the Inventory of impaired waters. Pollutants or stressors for the basin include: fecal coliform bacteria, turbidity, chloride, mercury, fish bioassessments, dissolved oxygen, ammonia, PCB, Acetochlor and Nutrient/Eutrophication.

Impaired Waters
TMDL List in the Minnesota River Basin



The Impaired Waters graph (above) shows the number of impaired waters that have been placed on the Impaired Waters (303(d) List. The increase is largely a reflection of more waters being assessed.

Clean Water Act

Originally passed in 1972, the Federal Clean Water Act established the basic structure for regulating discharge of pollutants into the waters of the United States. It requires all states to adopt water standards that protect the nation's waters. One of its most important functions is to spell out requirements on setting water quality standards for all contaminants in surface waters. These standards define how much of a pollutant can be in a surface and/or ground water while still allowing it to meet its designed uses – drinking water, fishing, swimming, irrigation or industrial purposes.

The Clean Water Act requires each state to do the following:

- Assign designated uses to waters and develop standards to protect those uses,
- Monitor and assess their waters,
- List waters that do not meet standards,
- Identify pollutant sources and reductions needed to achieve standards,
- Develop a plan to implement restoration activities.

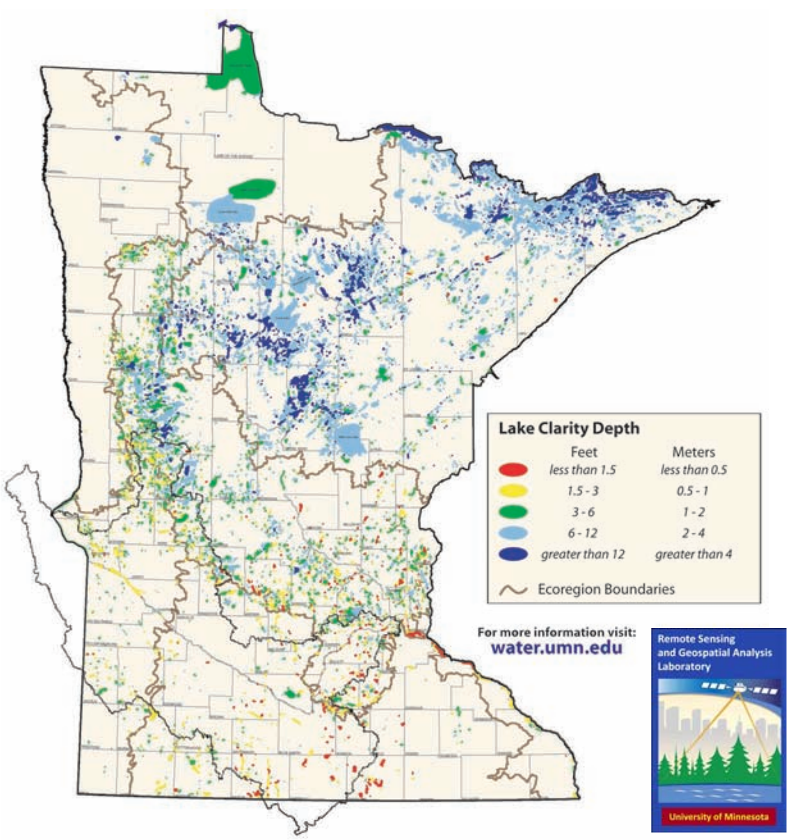
Lakes: Water Quality
Lakes studies show mixed trends

The Long View: Diatom Reconstruction of Lake Sediments

A study of fossilized single-celled organisms called diatoms was revealing about the history of Minnesota's lakes. MPCA and Science Museum of Minnesota scientists (Heiskary and Swain) collected sediment cores from 55 Minnesota lakes. They examined diatom communities and estimated the amount of phosphorus in each lake over time by identifying sediment layers from around 1750, 1800, 1970, and 1993. They discovered that most of the lakes they examined in Minnesota's cities and agricultural areas showed serious eutrophication (see box below) since European settlement. But they found no change in lakes studied in forested northern Minnesota.

Decreasing lake water clarity in southern Minnesota

A University of Minnesota study examined lake water clarity using satellite data from 1985-2005. Researchers found strong geographic patterns in Minnesota: lakes in the south and southwest have low clarity, and lakes in the north and northeast tend to have the highest clarity. Over the 20 year period, researchers found mean lake water clarity in central and northern Minnesota stable while decreasing water clarity trends were detected in southern Minnesota (Western Corn Belt Plains and Northern Glaciated Plains ecoregions) (Olmanson et al 2008).



Matt Niebuhr

Lake Minnewaska, Chippewa River Watershed

> ***"From the time they were created at the end of the Ice Age 10,000 years ago, Minnesota's lakes have been aging—slowly filling with sediment and increasing in fertility, with more plants, more plankton, less clarity."***
> Paula West
> Minnesota Lakes Association (DNR, 2003)

"People seem to realize the state of our lakes is changing," said Paula West, executive director of the Minnesota Lakes Association. "More weed growth, more boat traffic, and there's more development—their experience isn't what it used to be." Older residents "are concerned that their children and grandchildren won't be able to have the same experience that they did," West said.

"From the time they were created at the end of the Ice Age 10,000 years ago, Minnesota's lakes have been aging—slowly filling with sediment and increasing in fertility, with more plants, more plankton, less clarity. But human influence on land can kick this aging, or eutrophication, into high gear. Leaky septic systems, agricultural runoff, and storm-water runoff contribute nutrients to surface waters, fertilizing algae blooms and turning lakes green and cloudy. Phosphorus plays a particularly big role in fertilizing lakes" (DNR, 2003).

What is Eutrophic?

A eutrophic body of water, commonly a lake or pond, that has high primary productivity caused by excessive nutrients and is subject to algal blooms resulting in poor water quality. The bottom waters of such bodies are commonly deficient in dissolved oxygen which can be detrimental to aquatic organisms.

Lakes: Water Quality continued

Statewide Lake Monitoring—Secchi Disk Readings Show No Overall Patterns

Lake monitoring records indicate not all lakes are deteriorating measurably. "There are no overall patterns," said Steve Heiskary, Minnesota Pollution Control Agency lakes research scientist. Heiskary has compiled Secchi disk readings (a measure of clarity based on the visibility of a white disk submerged in the water) from the MPCA's Citizen Lake Monitoring Program (CLMP) on more than 800 lakes in Minnesota. "If we look at a hundred lakes for these kinds of trends," he said, "we'll find perhaps 70 percent with no trends at all" (DNR 2003).

Statewide Comparison of Lake Water Quality

Parameter	Northern Lakes and Forests	North Central Hardwood Forests	Western Corn Belt Plains	Northern Glaciated Plains
Total Phosphorus (ug/l)	14 - 27	23 - 50	65 - 150	130 - 250
Chlorophyll mean (ug/l)	4 - 10	5 - 22	30 - 80	30 - 55
Chlorophyll max (ug/l)	< 15	7 - 37	60 - 140	40 - 90
Secchi Disk (feet) (meters)	8 - 15 (2.4 - 4.6)	4.9 - 10.5 (1.5 - 3.2)	1.6 - 3.3 (0.5 - 1.0)	1.0 - 3.3 (0.3 - 1.0)
Total Kjeldahl Nitrogen (mg/l)	0.4 – 0.75	< 0.60 - 1.2	1.3 - 2.7	1.8 - 2.3
Nitrite + Nitrate-N (mg/l)	<0.01	<0.01	0.01 - 0.02	0.01 - 0.1
Alkalinity (mg/l)	40 – 140	75 - 150	125 - 165	160 - 260
Color (Pt-Co Units)	10 – 35	10 - 20	15 - 25	20 - 30
pH (SU)	7.2 - 8.3	8.6 - 8.8	8.2 - 9.0	8.3 - 8.6
Chloride (mg/l)	0.6 – 1.2	4 - 10	13 - 22	11 - 18
Total Sus. Solids (mg/l)	< 1 – 2	2 - 6	7 - 18	10 - 30
Total Sus. Inorganic Solids (mg/l)	< 1 – 2	1 - 2	3 - 9	5 - 15
Turbidity (NTU)	< 2	1 - 2	3 - 8	6 - 17
Conductivity (umhos/cm)	50 – 250	300 - 400	300 - 650	640 - 900
TN:TP ratio	25:1 - 35:1	25:1 - 35:1	17:1 - 27:1	7:1 - 18:1

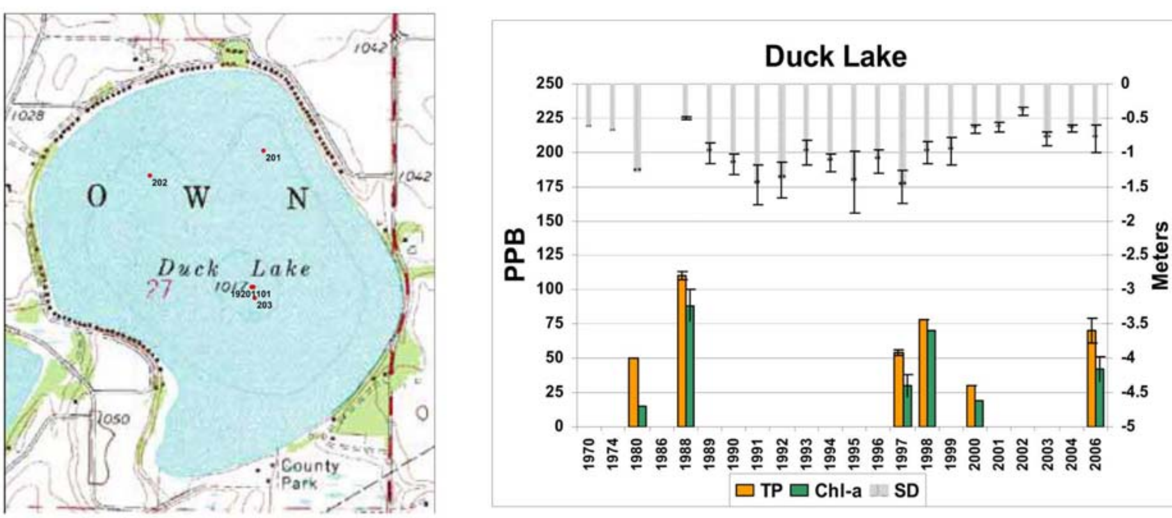
The Minnesota River Basin lies predominantly in the Western Corn Belt Plains (WCBP) and Northern Glaciated Plains (NGP) ecoregions. The chart above illustrates the different characteristics of this part of the state. Note the generally higher TP, chorophyll, Nitrates, TSS, and turbidity in these regions (MPCA, 2003).

Shallow Lakes—Nutrient Rich

A MPCA Study of Shallow Lakes of Southwestern Minnesota concluded: Most of the lakes are very nutrient rich. The high Total Phosphorus (TP) concentrations contribute to high chlorophyll-a, which is expressed as nuisance blooms of algae. Many of the lakes are dominated by blue-green algae that float near the surface and contribute to perceptions of "swimming impairment' or "no swimming." All lakes have highly agricultural watersheds, which is typical for lakes in these two regions. Agriculturally- dominated watersheds have higher P export values (expressed as stream TP) than watersheds characterized by forested and wetland land uses. Most of the lakes in this study did not have adequate data to assess trends. CLMP data, which is often a primary database for assessing trends in Minnesota lakes, are spotty or absent for most of the lakes. However, based on modern-day data (used in this report) and diatom-inferred data (Heiskary and Swain, 2002) no region-wide statements regarding trends can be made for the Western Corn Belt Plains (WCBP) and Northern Glaciated Plains (NGP) ecoregions.

Blue Earth County Lake Study—Mixed Trends

Figure 29. Duck Summer Mean Water Quality Trend and Sampling Locations



A MPCA study examined 6 lakes in Blue Earth County and found mixed trends. The example above shows Duck Lake, a small lake in Blue Earth County. It showed a significant decrease in transparency from 1997-2002. Total Phosphorus (TP) and chlorophyll-a are variable and show no consistent trends (MPCA, 2006).

Toxic Blue Green Algae—When in Doubt, Stay Out


Eileen Campbell

Toxic Blue Green Algal bloom
Crystal Lake, MN


Katie Brosch

Blue Green Algal bloom
Bass Lake, MN

Most algae are harmless but in high concentrations, a type of algae called "blue-green" (cyanobacteria) algae can be toxic. People or animals who contact toxic blue-green algae blooms can become sick. In recent years Minnesota has had increased reports and documentation of harmful algal blooms (HAB). People or animals may develop skin irritation or upper respiratory problems from exposure to HAB, and in extreme cases, dogs and other animals have even died after drinking lake water containing these toxins.

Blue green blooms typically occur on lakes with poor water quality (high in nutrients), and are often described to look like green paint, pea soup, or a thick green cake. A combination of factors will typically cause an algae bloom. Excessive nutrients, still waters, warm temperatures, and lots of sunlight all encourage the growth of blue-green algae. Recently Minnesota has done several studies and outreach efforts to better understand the risk of HAB and to improve public awareness. http://www.pca.state.mn.us/water/clmp-toxicalgae.html Unfortunately, there is no visual way to assess the toxicity of an algae bloom. Protect yourself and animals by staying away from dense algal blooms. When in doubt stay out!

Pesticides in Lakes

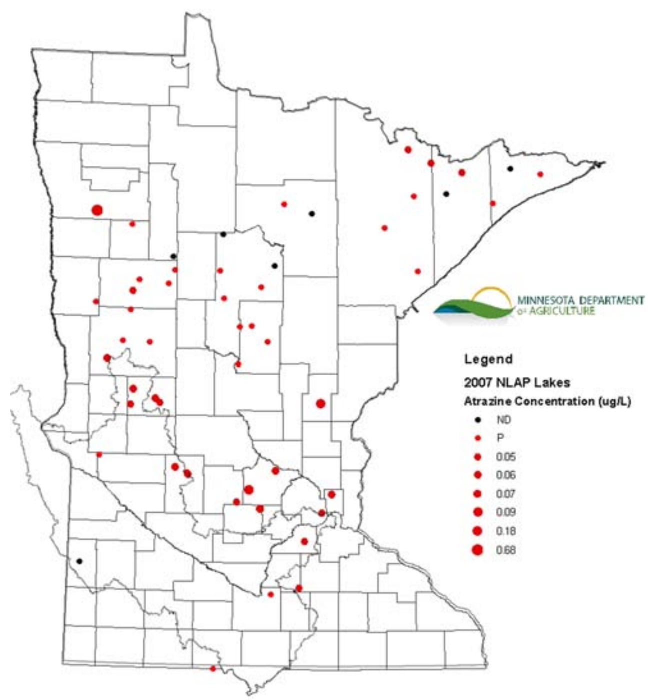
The Minnesota Department of Agriculture monitors for pesticides in lakes across the state. The MDA sampled 53 lakes for the 2007 Pesticides in Minnesota Lakes Study. Key findings include:

- **Pesticides Detected in Most Lakes:** A pesticide or a pesticide degradate was detected in 91 percent of the samples collected from Minnesota lakes. Concentrations of all detected pesticides were well below the Minnesota aquatic life standards and other reference values used by the Minnesota Department of Agriculture.

- **Atrazine** was detected in 87 percent of the 53 sampled lakes in Minnesota including lakes far from areas of assumed atrazine application. The concentration of atrazine was higher in samples collected from rivers then those measured in lakes located in the same Pesticide Monitoring Regions (PMR). Atmospheric deposition is suspected as the primary method of transport in lakes where pesticides, primarily atrazine, are detected far from areas of application. The degradate detected at the greatest frequency was deethyl atrazine a breakdown product of atrazine. Other pesticide degradates were found less frequently but at higher concentrations.

- **Agricultural Watersheds:** Lakes in lakesheds with row crop agriculture as a dominant land use had higher concentrations of total pesticides. This may be the result of direct runoff from adjacent lands or from greater atmospheric deposition due to closer proximity to areas of application. Lakes within lakesheds dominated by cultivated agriculture had substantially higher total pesticide concentrations than lakes within lakesheds dominated by urban and forest/water land use (MDA, 2008).

Pesticides Detected in Lakes: Atrazine in 2007



Fifty-five pesticide samples were collected from lakes throughout Minnesota in 2007. The map above shows Atrazine concentrations in lakes (MDA, 2008).

Ground Water: Quantity

Moderate to limited availability

Researchers are still learning about the extent of ground water supplies in the state. The Minnesota Department of Natural Resources (MDNR) is the primary state agency responsible for managing the quantity of Minnesota's ground and surface waters. The MDNR maps aquifers and issues water-use permits to balance competing demands and to protect natural resources.

Ground Water Availability

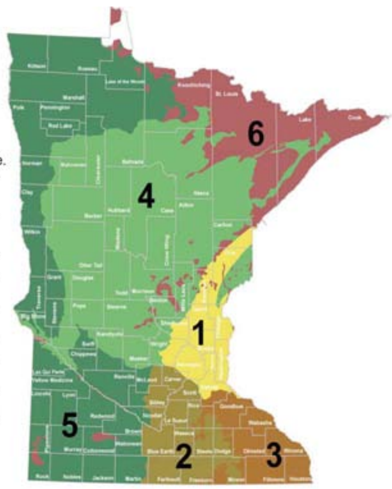
MDNR's map of ground water availability shows that Minnesota's ground water resources are not evenly distributed. Ground water in the Minnesota River Basin is illustrated primarily within areas "5" and "2" on the map at right. Ground water of adequate quality for drinking and other desired uses has always been scarce in southwest (and northwest) Minnesota because of the natural geologic and hydrologic conditions in these areas. To overcome the problem of finding water of adequate quality and quantity for drinking and other needs, rural water systems have been constructed in some communities in the southwest. (MDNR, 2005 map, MPCA 2007).

The MDNR is the agency responsible for ground water level monitoring. The extent of ground water supply is not well understood and is currently being studied. Jim Sehl, MDNR's ground water specialist in southern Minnesota stated that "in many cases, there's considerable uncertainty about how much water is available underground." Ground water level monitoring began in 1942 and now consists of a network of 750 observation wells across the state. Data from these wells is used to determine many issues including the impact of pumping and climate and to assess long term trends. There is a diversity of results depending on the aquifer type (unconfined, confined) location, and use. A couple examples from observation wells within the Minnesota River Basin provide some insight into ground water trends.

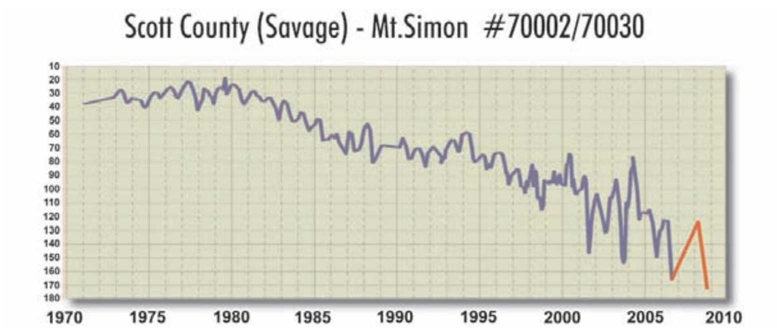
Minnesota's Ground Water Provinces

TABLE 1. Ground-water availability in the state.

Area	General Availability of Ground Water by Source: Surficial Sands	Buried Sands	Bedrock
1	Moderate	Moderate	Good
2	Limited	Moderate	Good
3	Limited	Limited	Good
4	Good	Moderate	Limited
5	Moderate	Limited	Limited
6	Limited	Limited	Limited

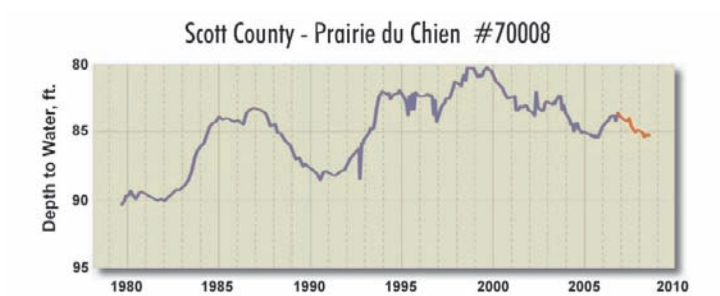


Source: MDNR 2005



Mt. Simon Aquifer (confined)

Results from the southern Metro observation well in Scott County near Savage showed water levels in 2008 the lowest ever measured and continues a downward trend in water levels that began in 1980. MDNR attributes this long term decline partly to climate and partly to pressures exerted on this aquifer from development in the area (MDNR, 2009).



Jordan and Prairie du Chien Aquifers (confined bedrock)

The Jordan and Prairie du Chien aquifers are bedrock aquifers (see map next page). The observation well in Scott County Prairie du Chien aquifer (above) has varied water levels from 1980 to present. The water levels have decreased since the levels observed in 2006 but the same decrease is not observed for the same aquifer in neighboring Rice and Hennepin county observation wells,

What is an Aquifer?

An aquifer is a body of rock or sediment that stores and transmits large amounts of ground water. An aquifer typically consists of sands and gravels with interconnected pore spaces or rocks with numerous interconnected fractures or cavities. Aquifers may be unconfined or confined.

Confined Aquifer—These aquifers are separated from the ground surface by a material of low permeability. Confined aquifers include buried drift and bedrock aquifers.

Unconfined Aquifer—In Minnesota, unconfined aquifers are typically composed of glacial sand and gravel. These aquifers have the water table exposed to the atmosphere. They are also called water table or surficial aquifers.

Ground Water: Water Quality

Nitrates and Arsenic are pollutants of concern

Ground Water Timeline

1960s
In the early 1960s the Minnesota Geological Survey (MGS) began to investigate Minnesota's bedrock aquifers, beginning with aquifers in urban areas.

1972
The MGS published a comprehensive survey on the geology of Minnesota that noted "reliable data on the … aerial extent of bedrock aquifers are generally only available for the major urban centers. However, even in the urban areas, specific information on the physical and chemical environments of the geologic units generally is poorly known."

1978
MPCA and USGS develop a ground water monitoring plan

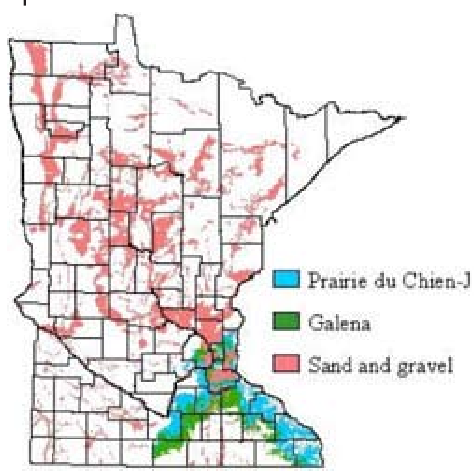
1989 Minnesota's Ground Water Protection Act
By the mid-1980s the presence of ground water contamination around the sate and its considerable impact on those affected was becoming well known. This protection act was triggered by severe drought in 1988.

1992-1996
MPCA collected ground water samples from domestic water supply wells from most Minnesota counties.

1998
Baseline Study published by MPCA provided information about ambient ground water quality in Minnesota's principal aquifers.

The Minnesota Pollution Control Agency (MPCA), Minnesota Department of Agriculture (MDA), and Minnesota Department of Health (MDH) each have important statutory responsibilities in protecting the quality of Minnesota's ground water, but only the MPCA and the MDA conduct statewide ambient ground water quality monitoring. The MDH conducts ground water monitoring in order to regulate public and private water supply wells and public water supplies, and evaluate the risk to human health from contaminants in ground water.

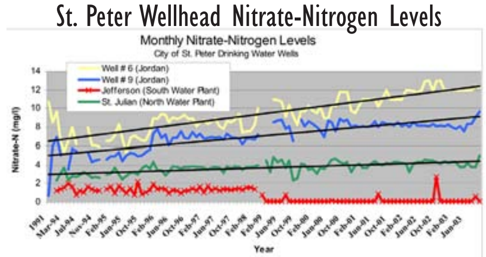
Aquifers Vulnerable to Pollution



Source: MPCA 2006

In Minnesota, geology largely dictates aquifers that are vulnerable to pollution. Aquifers that meet the designation of "vulnerable" include water table or unconfined aquifers, and the Prairie du Chien, Jordan and Galena bedrock aquifers at locations where there is no significant protective soil cover overlying the bedrock. The water table aquifers are typically composed of unconsolidated sand and gravel that was deposited by glacial activity in recent geologic time; these near surface aquifers occur throughout the state. The Prairie du Chien, Jordan, and Galena bedrock aquifers are considered vulnerable primarily in the Twin Cities and southeast Minnesota, where they outcrop at or near the ground surface.

St. Peter Wellhead Nitrate-Nitrogen Levels



Major Pollutants: Nitrates & Arsenic

Major ground water pollutants of concern in the basin include nitrates and arsenic. Nitrate is a common contaminant found in many wells throughout Minnesota. Wells most vulnerable to nitrate contamination include shallow wells, dug wells, and wells with damaged or leaking casings. Major sources of nitrate contamination can be from fertilizers, animal waste, and human sewage. Arsenic occurs naturally in some soil and rock and can leach into groundwater. Almost all arsenic in drinking water is from underground deposits of naturally occurring arsenic. Statewide arsenic sampling in Minnesota indicates that a significant area of the state has detectable concentrations of arsenic in ground water (MCPA, 1995), Approximately 14% of sampled wells exceeding the arsenic standard of 10 μg/l., Arsenic is particularly concentrated in western Minnesota where over 50% of the 900 sampled private drinking water wells had arsenic over 10 μg/l (MDA, 2001).

Municipal Systems - MDH

Municipal systems are monitored closely by MDH to meet health standards. Their source water protection program is designed to help prevent contaminants from entering public water sources. The program includes wellhead protection (capture zone for the well), source water assessments (description of water source), and where needed protection of surface water intakes.

St. Peter Wellhead Protection Program
States are required to have wellhead protection programs under the provisions of the 1986 amendments to the federal Safe Drinking Water Act. A case study example includes the St. Peter Wellhead Protection Program where nitrate is the primary contaminant of concern. The graph (at left) shows nitrate concentrations steadily increasing from 1991-2003. The city blends water from different wells to stay within public health guidelines (BNC, 2003).

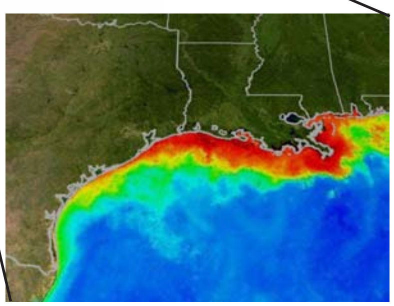
Downstream Impacts: Nitrates & The Dead Zone

A substantial contributor of excess nitrate

The Minnesota River and the Dead Zone

As the Minnesota River flows into the Mississippi River, it carries excess sediment and nutrients which impact downstream receiving waters.

The Minnesota River has been identified as a substantial contributor of excess nitrate to the Mississippi River and the Gulf Region.



NASA Visible Earth Program
Image from 2004

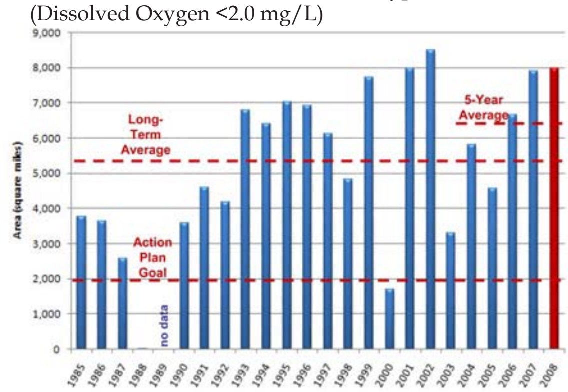
In 2008, the Dead Zone in the Gulf of Mexico stretched 7,988 square miles measuring second largest since measurements began in 1985. Source: NOAA, 2008

Science Museum of Minnesota

Gulf of Mexico algal blooms

Size of the Gulf of Mexico Dead Zone

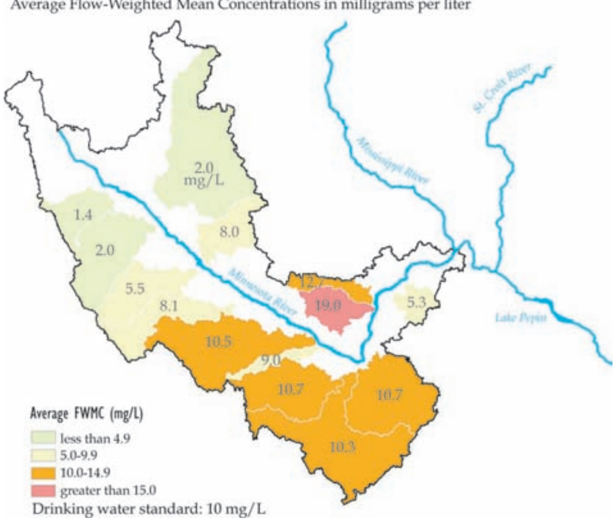
Area of Mid-Summer Bottom Water Hypoxia (Dissolved Oxygen <2.0 mg/L)



The size of the Gulf of Mexico Dead Zone is increasing. The average size of the Dead Zone over the past 5 years has been 6,600 square miles. The long term average is 5,300 square miles (NOAA, 2008).

Total Nitrate-Nitrogen

Average Flow-Weighted Mean Concentrations in milligrams per liter



This map shows the average flow-weighted mean concentrations of Nitrate-Nitrogen across the Minnesota River Basin 2000-2005. Elevated Nitrate levels can stimulate excessive levels of algal growth in streams.

Met Council

Algal blooms and dead fish

What is the Dead Zone?

In recent years, this problem has been particularly severe in the Gulf of Mexico where development of a hypoxic zone (hypoxia means "low oxygen") has been linked to elevated nitrate levels carried to the Gulf by the Mississippi River. Reduced oxygen levels in the hypoxic zone, brought on by decomposition of algae, have damaged the shellfish industry and continue to threaten the aquatic ecosystem of the Gulf Region.

Downstream Impacts: Sediment, Phosphorus & Lake Pepin

Lake Pepin is filling in with sediment at about 10 times its natural rate. At this rate, it will be completely filled with sediment within 340 years.

Lake Pepin lies downstream of the confluence of the Minnesota and Mississippi Rivers. It is a naturally occurring lake, and part of the Mississippi River on the border between Minnesota and Wisconsin.

Elevated Phosphorus Levels

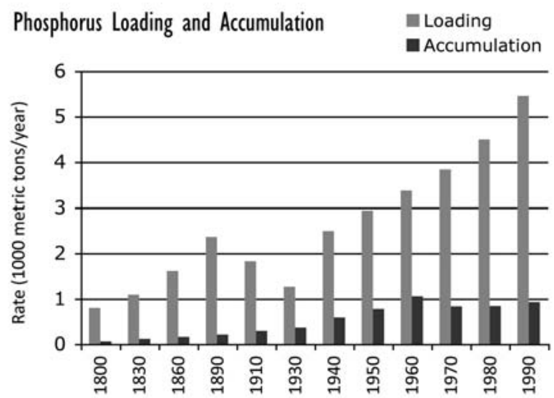

Met Council

Lake Pepin

Phosphorus is accumulating in the sediment at 15 times the natural rate. Phosphorus loading to the lake appears to have increased by about seven times (or more) above natural rates. Lake water Total Phosphorus concentrations have increased from about 50 ppb (parts per billion) to 200 ppb, making Lake Pepin highly eutrophic. Eutrophic means waters rich in mineral and organic nutrients promote a proliferation of plant life, especially algae (see photo below), which reduces the dissolved oxygen content and can cause fish kills.

Lake Pepin is filling in

As the Minnesota River flows into the Mississippi, it carries excess sediment and nutrients. Three rivers contribute sediment to Lake Pepin: The Minnesota, St. Croix, and Mississippi Rivers. Scientists have studied sources of sediment into the lake and determined that the Minnesota River contributes approximately 85 percent of the sediment load.

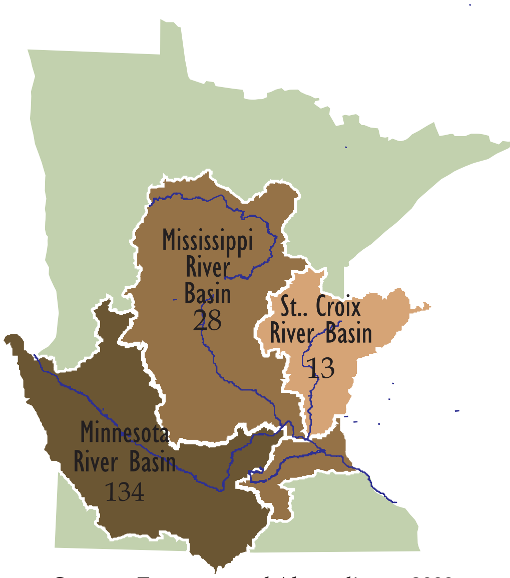


Total phosphorus loading and accumulation from 1800 to 1990. Source: Engstrom and Almendinger, 2000


Met Council

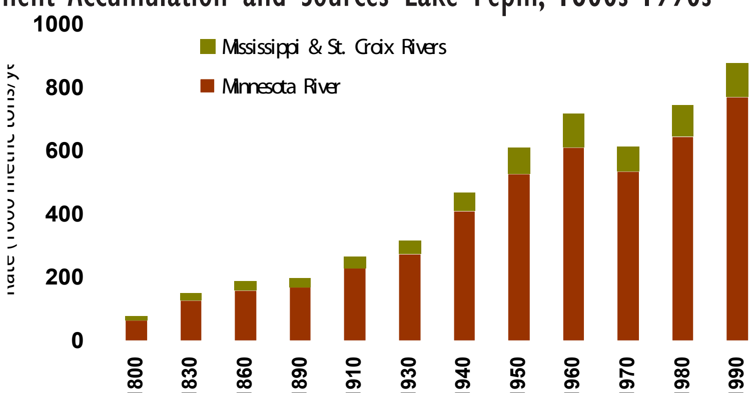
Excess phosphorus concentrations can lead to algal blooms in Lake Pepin.

Total Suspended Sediment Yield
(Pounds per acre, per year)



Sources: Engstrom and Almendinger, 2000
Nater and Kelley, 1998

Sediment Accumulation and Sources Lake Pepin, 1800s-1990s



Sources: Kent Johnson, Metropolitan Council, 2000 & Engstrom and Almendinger, 2000