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**Fifth Joint Conference on  
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Proceedings of a Conference Sponsored by  
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**SESSION VIII: LAND USE AND RURAL DEVELOPMENT**

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**PAPER 1: SOME MAJOR TRENDS AFFECTING THE STRUCTURE  
OF AGRICULTURE IN MINNESOTA AND THE UNITED STATES**

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Abano Terme - Padova, Italy  
June 17-18, 1996

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SOME MAJOR TRENDS AFFECTING THE STRUCTURE OF AGRICULTURE IN  
MINNESOTA AND THE UNITED STATES\*  
by

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I. INTRODUCTION

Two of the major trends shaping the evolution of agriculture in the United States are reduced diversification and increased risk in grain-crop production. This paper will attempt to document these trends since 1950, with data for one state, Minnesota. Since the state produces no cotton, rice, tobacco, or sub-tropical fruit and vegetable crops, there can be no pretension that it represents the full range of land use in U.S. agriculture. Minnesota has been a significant producer of all of the principal grain crops, livestock products, sugar beets, and oil seeds, and it bridges the boundary between the dairy belt and the grain belt in the Mid-West. With these limitations, Minnesota data provide revealing evidence of changes over the half-century since World War II that are redefining the structure of American agriculture.

The primary data sources are the time series of annual data maintained by the Minnesota Agricultural Statistics Service, supplemented by data from annual studies of the Minnesota Rural Real Estate Market, conducted by the University of Minnesota.

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\* Paper presented at the Fifth Joint Conference on Food, Agriculture and the Environment, sponsored by the University of Padova and the University of Minnesota, Abano Terme, Italy, June 17-19, 1996. I am especially indebted to Molly Wenner for help in data processing, and to the Minnesota Agricultural Experiment Station for financial support.

## II. REDUCED DIVERSIFICATION

One of the most emphatic trends is the decline in diversification in crop land use. The data are summarized in Table 1, for groups of crops, averaged over 5-year intervals since 1950-54. At mid-century, the crops that are now the state's three major crops--corn, soybeans, and wheat--accounted for 40% of the acreage of harvested crops. This percentage increased steadily to 1990-94, when these three crops accounted for 75% of all land in harvested crops. This is not monoculture, although on individual farms it sometimes is, but it exhibits a striking increase in dependence on only three crops.

Perhaps the most remarkable feature of this 45 year history of land use shifts in Minnesota is the relative stability in acres of corn harvested for grain. The peak 5-year averages were in 1955-59 and 1980-84, with just over 6 million acres. The lowest levels were in 1950-54, 1965-69, and 1985-89, when harvested acres averaged between 5.4 and 5.48 million acres. If ten-year periods are selected, the annual averages were 5,701,000 acres in 1950-59 and 5,710,000 acres in 1985-94. Corn acreage harvested in aggregate has been virtually stable since 1950. The data for corn and other principal crops are shown in Table 2.

The contrast with soybeans is dramatic. Harvested acres per year averaged 1,349,000 in 1950-54 and 5,190,000 in 1990-94, an increase of 3,841,000 acres, or just under 3-fold. Average annual harvested acres declined in only one five-year period, 1960-64. With this exception, the acreage increase in soybeans has been

Table 1. MINNESOTA: Shifts in Acres Harvested of Principal Crops, 5-Year Averages, 1950-54 through 1990-94

Crop(s)	ITEM	1950-54	1955-59	1960-64	1965-69	1970-74	1975-79	1980-84	1985-89	1990-94
		000 Acres or Percent								
Corn	ACRES	7,721	9,315	9,235	9,620	11,156	12,971	13,761	12,893	13,669
Soybeans	% of Total	40.17	49.00	51.73	54.57	60.22	64.32	68.22	69.77	74.53
Wheat	ACRES	6,443	5,187	4,211	3,922	3,564	2,967	2,432	1,843	1,291
Barley	% of Total	33.52	27.29	23.59	22.25	19.24	14.71	12.06	9.97	7.04
Oats	ACRES	3,807	3,667	3,637	3,422	3,130	3,122	2,862	2,960	2,310
Rye	% of Total	19.81	19.29	20.37	19.41	16.90	15.48	14.19	16.02	12.60
All Hay	ACRES	1,249	840	771	664	675	1,105	938	527	754
Flax	% of Total	6.50	4.42	4.32	3.77	3.64	5.48	4.65	2.85	4.11
Sunflowers	ACRES	(a)	(a)	(a)	(a)	(a)	(a)	178	256	316
Sugar Beets	% of Total	(a)	(a)	(a)	(a)	(a)	(a)	0.88	1.39	1.72
Potatoes	ACRES	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Dry Beans	% of Total	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Sweet Corn	ACRES	19,220	19,009	17,854	17,628	18,525	20,165	20,171	18,479	18,340
Peas	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TOTAL, All Listed Crops	ACRES	19,220	19,009	17,854	17,628	18,525	20,165	20,171	18,479	18,340
	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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Table 2. MINNESOTA: Acres Harvested of Principal Crops, 5-Year Averages, 1950-54 through 1990-94

Crop	1950-54	1955-59	1960-64	1965-69	1970-74	1975-79	1980-84	1985-89	1990-94
	000 Acres								
Corn	5,399	6,002	5,969	5,429	5,898	5,934	6,074	5,480	5,940
Soybeans	1,349	2,541	2,372	3,283	3,517	3,916	4,756	4,820	5,190
Wheat	973	772	894	908	1,741	3,121	2,931	2,593	2,539
Barley	1,178	962	769	732	777	922	899	919	720
Oats	5,125	4,144	3,365	3,108	2,673	1,952	1,412	870	545
Rye	140	81	77	82	114	93	121	54	26
All Hay	3,807	3,667	3,637	3,422	3,130	3,122	2,862	2,960	2,310
Flax	1,110	686	535	371	262	192	92	24	15
Sunflowers	(a)	(a)	25	56	192	597	518	114	289
Sugar Beets	16	69	104	139	129	242	255	314	377
Potatoes	78	85	107	98	92	74	73	75	73
Dry Beans	(a)	(a)	(a)	(a)	(a)	(a)	66	65	113
Sweet Corn	(a)	(a)	(a)	(a)	(a)	(a)	112	117	127
Peas	(a)	(a)	(a)	(a)	(a)	(a)	(a)	74	76
<b>TOTAL</b>	<b>19,220</b>	<b>19,009</b>	<b>17,854</b>	<b>17,628</b>	<b>18,525</b>	<b>20,165</b>	<b>20,171</b>	<b>18,479</b>	<b>18,340</b>

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continuous since 1950. In 1950-54, corn acreage harvested was four times soybean acreage. In 1990-94, corn acreage was only 14.5% above soybean acreage. The rise in harvested acres in soybeans has dominated changes in cropland use in Minnesota since the Second World War.

Although lagging well behind corn and soybeans in total acres harvested, the rise in wheat acreage since 1950 has been substantial, but uneven. With well under one million acres in the 1950's, wheat peaked at over three million acres in the ten years from 1975 to 1984, only to fall back to just over two and one-half million acres in 1990-94. A feature of this change has been the virtual disappearance of wheat in the southern half of the state, where corn and soybeans predominate.

While these three crops provide the principal evidence of a decline in diversity in land use, the shift in wheat and soybean acreage has also been geographic in nature. In 1950, the Northwest Crop Reporting District of the state accounted for 56% of wheat acres harvested. In 1994 this had increased to 72%.

For soybeans, the South East and South Central Crop Reporting Districts had 46% of harvested acres in 1950 and only 32% in 1994. The Southwest District led the state in 1994 with 24% of soybean acres harvested. In 1950 it had accounted for only 17%

The rise of corn, soybeans, and wheat as the state's dominant crops has thus been associated with a geographic concentration in more sharply defined production areas, especially for soybeans and wheat.



With over 3.8 million more acres in soybeans in 1990-94 than in 1950-54, and over 1.6 million more acres in wheat, from where did the additional 5.4 million acres come? On a state-wide basis, the answer is clear from Table 2: From the conversion of land that in the 1950's had produced oats, hay and flax. The biggest shifts involved oatland. Minnesota in 1950-54 had an annual average of 5.1 million acres in harvested oats. In 1990-94 this had fallen without interruption to just over 0.5 million acres. The decline of oats stands out as the major contributor to the expansion of the soybean.

The other major source for soybean land has been hayland, which declined by one and one-half million acres from 1950-54 to 1990-94. It is revealing to note that the major sources of land for the expansion of soybeans in Minnesota since 1950 were oats and hay, or in other words, horse-feed. The shift to tractor farming in the Corn Belt, retarded during the years of depression and war, 1930-1945, was resumed after the war on a scale that lifted the soybean to the status of America's second most valuable crop. Minnesota's location at the cool northern fringe of the Corn Belt gave it ample supplies of oats and hayland to contribute to this major conversion in land use.

The other massive shift in harvested cropland involved flax. Spurred by wartime demand for oils, Minnesota ended the war with over a million acres in flax, in 1950-54. By 1990-94, flax had virtually disappeared. Given its locational and climatic tolerances, flaxland contributed heavily to the expansion in wheat

acreage (as did oatland), and to the shift to sunflowers and sugarbeets.

The data in Table 2 also illustrate an important dimension of land use shifts in Minnesota, involving crops that were of relatively minor importance in 1950. In 1990-94, the state had over one million acres in sunflowers, sugarbeets, potatoes, dry (edible) beans, sweet corn and peas. With the exception of sugarbeets and potatoes, these crops were not even separately reported in the 1950's. This moderates the stress on the state's growing dependence on only three major crops. Although the specialty crops listed above occupied only 5.75% of the harvested cropland in 1990-94, they contributed a disproportionately higher percentage of value-added in agricultural production, adding some diversity to regions otherwise committed to corn, soybeans, and wheat.

### III. INCREASED RISK

A second trend shaping American agriculture is the increased variability in yields and total output of major grain crops in recent decades. This emerges clearly from Minnesota data in Table 3, showing coefficients of variation at 5-year intervals, 1950-1994, for the state's three major grain crops, corn, soybeans, and wheat.

The coefficients of variation (the standard deviation divided by the mean and expressed as a percentage for each five year period), tell us, in approximate terms, the range above or below the mean that would include two-thirds of the observed data. For

Table 3. MINNESOTA: Corn, Soybeans, and Wheat Coefficients of Variation at 5-year Intervals, for Acres Harvested, Yield, and Production, 1950-1994.

Crop	(Standard Deviation/Mean x 100, in Percent)									
	1950-54	1955-59	1960-64	1965-69	1970-74	1975-79	1980-84	1985-89	1990-94	
I. Acres Harvested										
Corn	3.1	8.7	8.3	7.3	8.2	3.9	15.9	11.6	13.1	
Soybeans	28.6	14.0	12.3	6.1	18.4	19.2	6.9	3.6	7.6	
Wheat	17.6	17.9	13.4	13.5	41.6	18.9	19.8	8.4	12.2	
II. Yield										
Corn	12.7	7.7	9.2	12.3	15.8	23.8	11.6	19.9	23.4	
Soybeans	10.2	7.5	10.1	12.1	13.2	19.9	4.9	15.0	22.1	
Wheat	10.7	18.7	7.9	14.4	15.3	11.2	15.1	28.9	27.4	
III. Production										
Corn	14.8	6.0	11.5	12.4	14.3	26.9	24.8	25.3	31.9	
Soybeans	39.0	11.8	16.6	11.5	25.7	33.0	9.6	15.1	24.6	
Wheat	22.7	29.3	15.1	25.6	40.7	20.8	21.7	32.0	38.8	

Source: Minnesota Agricultural Statistics Service, Annual Reports

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example, a coefficient of variation of 20 indicates that in about two-thirds of the years the recorded data fell within a range set by 120 and 80 percent of the mean for that 5-year period. Roughly one-third of the observations fell above or below this range.

For acres harvested (Segment I in Table 3), variability has been relatively low for corn, although rising since 1980. Variability for soybeans was greatest in years of most rapid expansion in acreage in the 1950's and 1970's, but quite modest since 1980. Over the 45-year period, the greatest variability in acres harvested has been in wheat, especially in the 1970's.

With two notable exceptions, soybeans in 1950-54 and wheat in 1970-74, the coefficients of variation for acres harvested have been under 20 for all three crops and nine 5-year periods since 1950. While shifts in acreage harvested have contributed to variability in total output of corn, soybeans, and wheat in this 45-year period, the effects have been relatively small.

A different pattern emerges with respect to yields (Segment II of Table 3). With the exception of wheat in 1955-59, the 5-year coefficients of yield variation were under 15 for all three crops throughout the 1950's and 1960's. This relative stability changed in the 1970's, with marked increases in yield variability for corn and wheat and a more erratic but still upward path for soybeans.

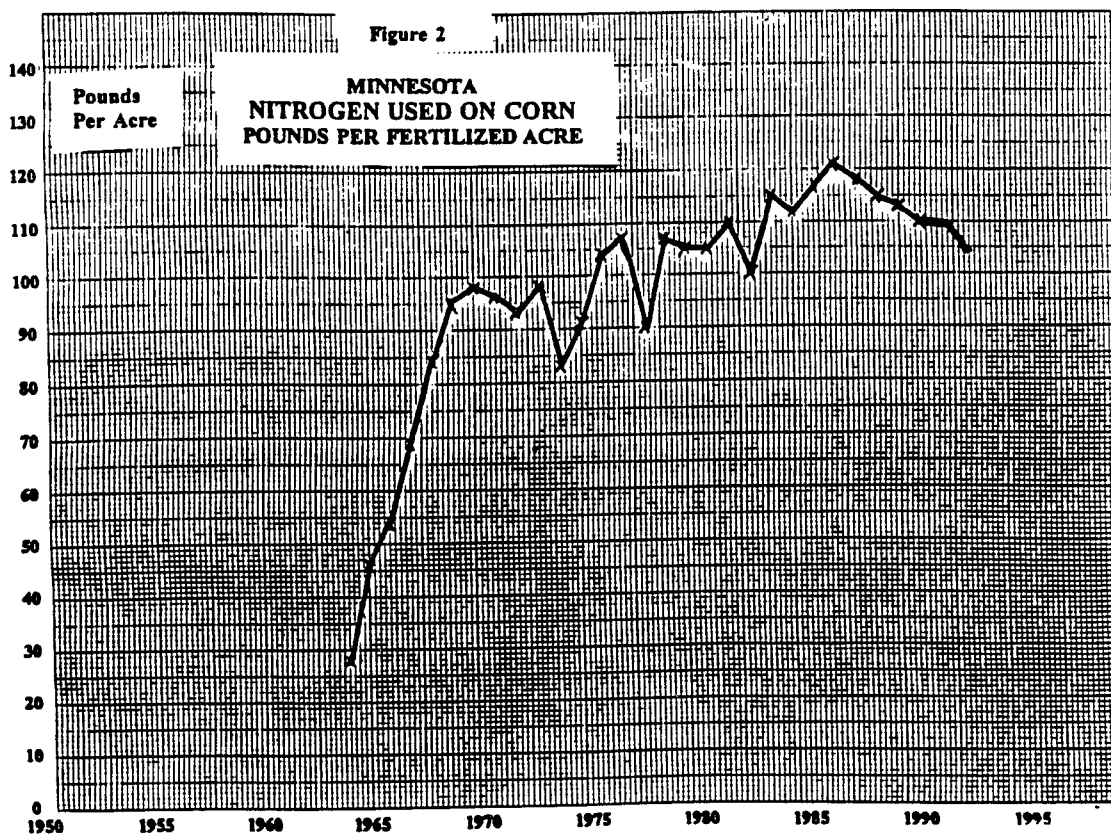
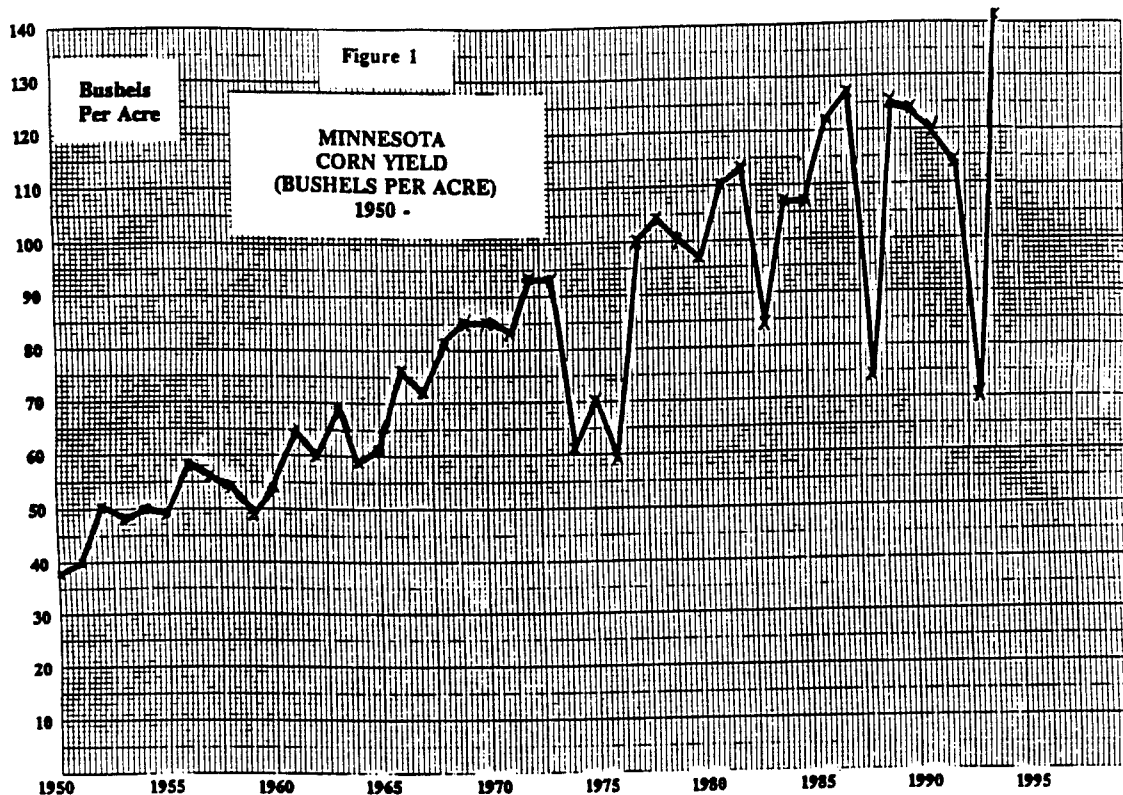
With the exception of soybeans yields in 1980-84, a general pattern of increased coefficients of yield variation characterized the 25 years from 1970 through 1994, for all three crops. The most significant increases in variability were in corn yields after

1975, and in wheat yields after 1985.

The combined effects of variability in acres harvested and in yields are shown in the coefficients of variation for total output in Segment III of Table 3. Here there are some surprises. Measured by 5-year periods, the greatest change over time has been the dramatic upward shift in variation in corn output. From 1950-54 through 1970-74, the coefficients of variation in total output of corn were never above 15. After 1975, the 5-year coefficients never fell below 25, and were roughly twice the levels prevailing from 1950 to 1974. For Minnesota, corn production has become a distinctly more risky enterprise over the past 20 years, with yields contributing virtually all of the variance in output.

Yield variance in corn deserves a closer look. As shown in Figure 1, variability in corn yields was low from 1950 to 1973, around a strongly upward trend. In this period yields more than doubled. After 1973, a pattern of high variability is apparent, with sharp declines in 1974-76, 1983, 1988, and 1993.

The timing of this increase in yield variability gains significance when compared to Figure 2, showing the increased use of nitrogen fertilizer on corn in Minnesota. In the mid-1960's, although an estimated 80 percent of all acres planted to corn received some nitrogen, the rate of application was low. Application rates more than tripled from 1964 to 1970, from 28 to 98 pounds per acre, and continued a more gradual upward trend to a peak of 121 pounds in 1987. After 1970, from 90 to 98 percent of all corn acres received some nitrogen.



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While variations in weather unquestionably played a role in yield variability, it is not clear that the weather became sharply more variable after the 1970's. What is clear is that the recent increased variability in corn yields has been associated with increased use of nitrogen.

This suggests a hypothesis: It is possible that the almost universal use of high-yielding hybrid corn varieties, depending on high plant densities per acre and high rates of nitrogen use to achieve their potential, have made corn production much more sensitive to temperature and rainfall variations. The data from Table 3 and Figures 1 and 2 suggest that this is an especially promising hypothesis in explaining increased risk in corn production in Minnesota.

Variability in total output of soybeans since 1950 has followed a more erratic path than that for corn. From the 1950's, through the 1970's, this was driven by the rapid expansion in acres harvested in all 5-year periods except 1965-69. This expansion slowed in the 1980's, with almost all of the variability in total output of soybeans since 1985 traceable to variation in yields.

Among the three crops, wheat has exhibited the most erratic pattern of variability in total output since 1950. This was driven by expansion from under one million acres harvested from 1950-54 to 1965-69 to over four million in 1976, followed by a sharp drop to just over two million acres in 1983, and relative stability at two and one-half to three million acres since 1984. Acreage variability was clearly a major contribution to swings in wheat

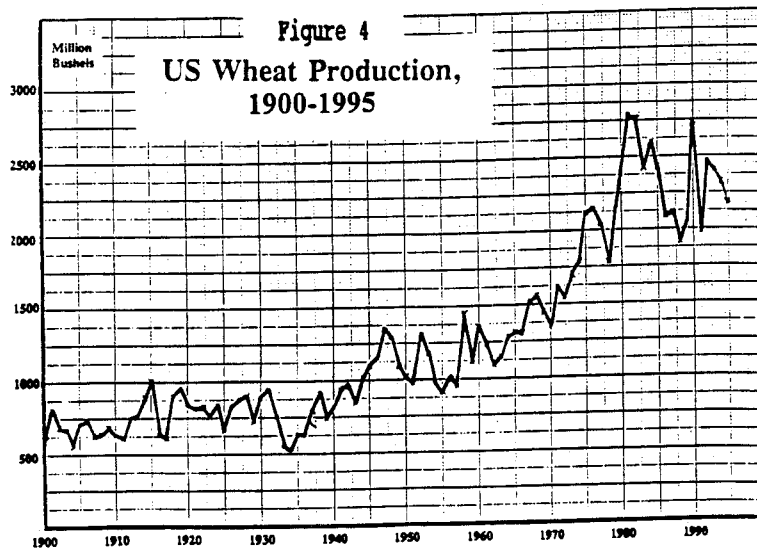
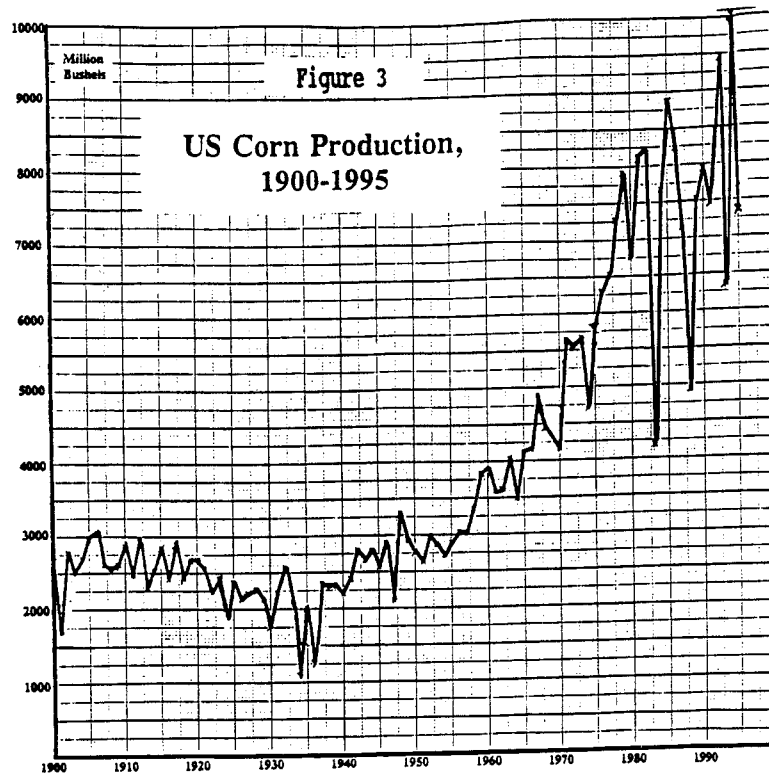
production into the 1980's. Since 1985, the driving force has been variability in yield.

The coefficient of variation in wheat production was over 20 in all but one of the nine five-year periods since 1950. For both corn and soybeans, it was over 20 in only four of the nine periods. In terms of production variability, wheat is Minnesota's riskiest crop.

Although the analysis to this point has focused primarily on one state, the increased variability in output is not confined to Minnesota. Figures 3 and 4 trace annual production since 1900 for the United States as a whole, for corn and wheat, the two crops exhibiting the greatest increase in output variance in recent years. Figure 3 for corn is revealing. Since 1970, the pattern of variability for the United States replicates that quantified above for Minnesota, with especially sharp deviations from trend after 1982. It is clear that the increased risk in corn production in Minnesota is a part of a nation-wide phenomenon.

Figure 4 for wheat output reflects the more modest increases in yields in the last half century, when compared to corn, and the more dispersed geographic base of United States wheat production. Corn in the United States is virtually a homogeneous product, and the Corn Belt is relatively compact. In contrast, there are many types of wheat--winter, spring, soft, hard, white, durum--supplying quite different markets. It is grown over a wider range of soil and climate zones than corn, making the swings in total output since the 1970's even more remarkable. As in Minnesota, wheat





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production in the United States has become a source of increased risk in farming over the past two decades.

There are other measures of risk. One concerns the growing dependence on only three major field crops, noted above. In addition to climatic and disease risk, this concentration on three crops introduces an especially significant element of international market risk. Corn, soybeans, and wheat are leading export crops, as shown in Table 4.

Since 1980, U.S. annual exports as a percent of production in the preceding crop year have averaged 25 percent for corn, 49 percent for soybeans, and 55 percent for wheat. The profitability of the three crops that occupy 75 percent of all harvested cropland in Minnesota is heavily affected by fluctuations in foreign markets. This adds a risk element to the production variability noted above that is especially relevant for soybeans and wheat.

For corn, the relatively low percent of export dependency is misleading, in that the volume of production is so much greater than for soybeans or wheat. Over recent decades the tonnage of corn produced in the U.S. has averaged well above the tonnage of soybeans and wheat combined. In only one year since 1975 has the volume of corn exported fallen below that of wheat. Corn has clearly acquired the status of an export crop. This is in contrast to estimates from the 1950's that 75% to 80% of all corn produced in the U.S. was fed to animals, primarily on the farms where it was produced.

Accompanying the loss of diversity in cropland use, and

TABLE 4:  
 UNITED STATES: Volume Exported of Corn, Soybeans, and Wheat, as a Percent of  
 Volume Produced in Preceding Crop Year

YEAR	CORN	SOYBEANS	WHEAT
	PERCENT		
1983	23	55	51
1984	44	57	65
1985	24	44	42
1986	14	48	41
1987	19	56	50
1988	24	55	71
1989	40	48	76
1990	31	44	51
1991	22	41	36
1992	21	49	66
1993	17	45	56
1994	21	43	54

Source: U.S. Department of Agriculture, ERS, Foreign Agricultural Trade of the U.S., various years. Includes exports of processed goods or products, in grain or seed equivalent. The series has not been published for years prior to 1983.

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increasing variability in output, we must add the high degree of export dependency in assessing the risk currently facing farming and farmers in Minnesota.

Increased variability in production of corn, soybeans, and wheat has been interpreted to this point as it affects farming risk in Minnesota and the United States. Another interpretation that deserves emphasis is its significance for world trade. The United States is the dominant supplier of corn and soybeans to world markets, as shown in Table 5. While world trade in wheat involves a larger number of exporting countries and a reduced percentage share for the United States, it has consistently been the largest supplier of wheat to world markets since the Second World War.

Variability in output of these three food and feed grains is thus not only of concern to the United States, but also threatens the export of this increased risk to the world grain and oilseed economy. This threat is particularly relevant in 1996, with reduced carry-over stocks and escalating prices. This underlines the need for more research to determine whether or not an assumption of increased output variability is a necessary component of high-input/high-output grain farming in the United States. The answer to this question has world-wide implications.

**TABLE 5:**  
**UNITED STATES:** Exports of Corn, Soybeans, and Wheat, as a Percent  
of World Exports, 1980-1994

YEAR	CORN	SOYBEANS	WHEAT
	P E R C E N T		
1980	41.5	60.4	14.7
1981	46.9	62.8	17.0
1982	47.6	63.7	15.7
1983	30.5	53.5	13.5
1984	42.5	54.4	13.9
1985	47.0	58.9	13.2
1986	44.1	53.9	10.7
1987	40.4	51.0	11.4
1988	31.3	44.6	9.8
1989	41.3	48.8	10.3
1990	42.1	50.9	12.6
1991	39.4	50.8	9.9
1992	45.6	51.8	11.9
1993	34.4	43.6	11.6
1994	45.6	51.2	11.9

Source: Statistical Abstract of the United States,  
various years.

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