

# Unexpected Impacts of Drought 2005 on Illinois Crop Yields: Are Weather-Crop Relationships Changing?

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## ABSTRACT

Rainfall across Illinois was much below normal from March through July 2005, initiating a severe growing season drought. Temperatures from June through September were above normal adding to the potential stress on corn and soybean crops. During the summer, crop experts predicted major yield reductions, and crop quality surveys showed ever growing problems from June through August. However, the 2005 harvest produced statewide corn and soybean yields that were above average, and the soybean yield of 47 bu/acre was the state's second highest on record. This outcome, in contrast to the dire in-season predictions and crop surveys, raises important questions about the level of understanding about the relationship of weather and crop yields. Genetic improvements and better farming practices likely have altered how weather impacts crop yields.

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## INTRODUCTION

Large parts of Illinois suffered through a relatively severe drought during the 2005 growing season. The drought was characterized by deficient precipitation across much of the state, coupled with high summer temperatures. The chronology of the precipitation and temperature conditions from March through September 2005 and the reactions of various persons and institutions to the conditions are presented initially. Then the crop-related impacts resulting from this 7-month (March-September) drought period are presented. Political action began in late June to seek relief assistance for Illinois farmers, because the agricultural sector is an important part of the state's economy. However, the final crop yields were much higher than expected, ending efforts to get relief and raising serious questions about the in-season predictions of low yields and crop surveys that had indicated poor crop conditions.

## THE DROUGHT AND REACTIONS

Statewide rainfall in March 2005 was 50 percent of average, being less than one inch in northern Illinois and three inches in deep southern Illinois (Fig. 1). The dry conditions were generally viewed as a blessing by farmers because they allowed early planting of corn. April rainfall continued the below normal trend (Fig. 1), being 1.1 inch below the statewide normal, and the statewide monthly temperature was much above normal (Fig.

2). Rainfall in May had an even greater departure below average, with a statewide average of 1.8 inches, which was 2.4 inches below the month's average and rated as the second driest May on record. The percent of average precipitation in each of Illinois' nine climate divisions fell below 65% for the month (Fig. 1). As a result, soil moisture from the surface down 20 inches at the end of May was well below average, being less than 75% of average across the state and less than 50% in parts of northern and central Illinois. The media began to carry stories about the emerging "drought" (Chicago Tribune, May 29), noting the drought was centered in Illinois and adjacent portions of surrounding states.

June conditions continued the dry regime with statewide rainfall being 1.8 inches below average (Fig. 1), and the statewide June temperature was 3.2°F above average (Illinois State Water Survey, July). Northern Illinois experienced the fifth warmest June since 1895 (Fig. 2). Near surface soil moisture amounts continued to fall in June with decreases of 20 to 70 percent across central and southern Illinois (Scott, July 7). At the deeper soil levels, 20 to 72 inches down, soil moisture continued to rapidly decline across the state, being less than half of the average across more than 50 percent of the state at the end of June. The emerging corn and soybean plants were using the soil moisture in the absence of adequate rainfall. Maps measuring existing droughts across the nation showed an area oriented southwest-northeast across Illinois and Missouri, and some portions in Illinois were classed as being an "extreme drought" (Farm Week, June 27).

In early June, crop experts and grain market experts began expressing concern over the developing agricultural drought in Illinois, and this was widely reported in the media (Farm Week, June 6, June 13). Atmospheric scientists reported on the drought's severity and compared it to the severe drought of 1988 (Farm Week, June 27). Concerns of farmers and agricultural interests in Illinois led the Governor of Illinois to assemble the state's Drought Task Force on June 26. They announced that the state's rainfall for March-June was the third lowest since 1895 and reported there was potential for severe agricultural impacts. Temperatures in June had been well above average adding to the crop stress. These warm and dry conditions were expected to severely impact the state's corn crop that had been planted early and was nearing its pollination stage which determines the crop's size and quality.

Farm leaders called for action and in mid-July urged the state to seek federal disaster assistance for Illinois farmers now expected to have poor crop yields in 2005. As a result, the quality of the crops in all 102 Illinois counties was assessed, and this effort found that within 101 counties more than 30 percent of the corn crop was in serious condition. The 30-percent level on one major crop is the level needed to qualify for federal aid. In late July the Governor of Illinois sent a formal request to the federal government (FEMA) for disaster assistance for 101 counties. (Farm Week, August 1a).

Conditions during July remained dry over half of the state (Fig. 1) and temperatures remained above average across the entire state (Fig. 2). Although rainfall in July, a critical time for corn, was well below average in the northwestern half of Illinois, the timely occurrence of rainfall from the passage of tropical storm Dennis on July 11-13 helped corn yields in the southern two-thirds of Illinois. A prior corn-weather study found that

rainfall in the 2-week period of June 29-July 12 enhanced corn yields more than rain at any other time (Changnon and Neill, 1968).

Crop experts agreed that corn and soybean crops were in worse shape than the yield estimates issued by the USDA in early July (Farm Week, July 18a), and the National Weather Service indicated that the July rains were insufficient to halt the drought (Farm Week, July 18b). Statewide crop surveys on July 25 reported that 55 percent of the state's corn crop was in poor to very poor condition (Farm Week, July 25). At the end of July, the average statewide rainfall was below normal. The March-July rainfall across the state was 8 inches below average and the number of days with temperatures of 90 degrees or higher varied across Illinois, being 8 to 20 days above average. National maps of drought impacts issued by the USDA in late August showed that the northwestern half of Illinois was experiencing extreme drought, the worst possible classification, and the rest of Illinois was in moderate drought (Fig. 3).

In a crop report issued in early August, the USDA predicted that corn yields in Illinois would be low, estimated at 125 bu/acre, as compared to an average of 142 bu/acre, and soybean yields were estimated at 39 bu/acre, 3 bushels less than average. Predicted corn yields in the Northwestern, Northeastern, Western, and Central crop districts were estimated to be much below average by 15 to 30 bushels. By early August crop experts reported that any future rain would not help the corn crop and might be of small aid to the bean yield (Farm Week, August 8a).

By the end of August, most experts believed the impacts of the on-going drought would be very serious for the Illinois corn crop, although soybean yield outcomes were seen as uncertain. (Drought Response Task Force, September 7). Crop surveys done in mid-August rated 61 percent of the Illinois corn crop as being poor to very poor, with 41 percent of the soybean crop in the same class (Farm Week, August 15). However, a late-August tropical storm brought considerable rainfall across the southeastern half of Illinois that was sufficient to bring August rain totals there above average (Fig. 1). A record number of tropical storms, a total of four, brought rain to many parts of Illinois between mid-June and mid-September, and the total rain from these storms was a significant contribution to the summer total rainfall (Fig. 4), ranging from 20 to 35 percent of all rains in the southeastern half of the state.

Farmers and crop experts began issuing reports in late August about wide differences in expected yields within fields, between fields, and between counties. Crop surveys done in many Illinois fields in late August found wide differences within many counties, and the lowest statewide corn yield found was 6.7 bu/acre and the highest was 203 bu/acre (Farm Week, August 29). Secretary of Agriculture Johanns came to Illinois in late August and inspected crops in northern Illinois, declaring them to be badly damaged by the drought and worthy of federal disaster aid (Farm Week, September 5).

Assessments of crop conditions made during the summer are shown in Table I. The quality of the state's corn crop dropped from 49% good in June to only 12% good by early August. Very poor corn was only 2% of the crop, as rated in early June, but this grew to 29% of the crop by early August. The status of the soybean crop also shifted dramati-

cally, from 55% rated as good or excellent in early June to only 19% good or excellent two months later.

Harvest began in September with hot and dry conditions persisting through the first three weeks of the month, helping the crops to dry down (Fig. 2). By September 15, 6% of the state's corn crop had been harvested and 8% of the bean crop. By September 18, 74 percent of the state's corn was mature (National Weather Service, September 20). Many farmers were expressing surprise at their yields with many being higher than expected. By October 23, 89 percent of the corn crop was harvested and 93 percent of the state's soybean crop. Interestingly, the USDA's yield estimates issued in early September called for higher yields, to 136 bu/acre for corn, an 11 bushel increase over their August estimate, and 41 bu/acre for soybeans. Many crop experts were surprised by these increases and questioned the USDA estimates (Farm Week, September 19).

The final statewide average corn yield was 143 bu/acre, which is 1 bushel above the 1994-2003 average but 37 bushels less than the record high yield of 2004. The statewide average soybean yield was 47 bu/acre, 5 bushels above average and the second highest soybean yield on record. The record high set in 2004 was 50 bu/acre. The prior severe drought in Illinois during 1988 produced a 42% reduction in Illinois corn yields and a 26% reduction in soybean yields (Riebsame et al., 1991).

The spatial distribution of the 2005 yields across Illinois revealed wide differences. Tables II and III present the corn and soybean yield values for the state's nine crop districts, showing that corn yields were above average in 5 of 9 districts, with yield averages greater than 10 bushels above average in the East, Southwest, and Southeast districts. The Northwest, Northeast, Western, and Central districts had below average yields, but the only sizable decrease was in the Northeast (14 bushels/acre). Soybean yields were above average in the state's nine crop districts, being more than 5 bushels above average in the East, East Southeast, Southwest, and Southeast. The harvested yields revealed those of both crops were much higher than had been expected in most of Illinois. The large difference between the low yields predicted during the summer and indicated in the crop surveys (Table I), and the final above average yields is a major question needing explanations. Some crop experts credited this surprising outcome to a variety of factors including the timeliness of the rains that did occur, better hybrids, and improved farm practices. Bioengineered corn varieties (e.g., biotech) developed very deep and complex root systems during 2005 and were found to produce yields 10- to 30-bushels per acre more than standard corn varieties (Farm Week, December 19). Research has shown that the continuing improvements in seed genetics and farming practices have led to an increase in corn yields at a rate of one percent per year (Troyer, 2000). This means a gain of 9 bu/acre over the past five years.

The dry conditions in May and June 2005 led corn plants to deep root and survive from the existing soil moisture. Fortunately, precipitation in the four months before March 2005 was much above normal, re-charging the soils at all depths with moisture sufficient to sustain corn growth. A second critical weather condition occurred on July 11-13 when rains from tropical storm Dennis fell over most of Illinois, when corn was in its yield critical pollination stage. This was in the 10-day period when prior research has shown rainfall to be most critical of the season for corn yields (Changnon and Neill, 1968). A

third timely weather event were rains in mid- to late-August. These supplied needed water to the soybean crop and helped result in high bean yields.

The drought produced mixed outcomes for crop diseases and insect pests that could have reduced yields. The dry conditions were considered favorable for the Japanese beetle population and aphids. The drought also left the corn crop vulnerable to the corn root-worm, and dry soils limited plant uptakes of pre-applied herbicides. However, the drought and lack of rain held off feared infestations of the Asian soybean rust (Farm Week, July 11) and many wheat diseases.

The drought did not hurt the state's winter wheat crop harvested in mid-summer as wheat yields averaged 64 bu/acre, just one bushel below the record set in 2004. The heat and dryness had detrimental effects on garden crops, and pumpkin yields were reduced (Farm Week, September 5). Orchard crops also were hurt by the heat, especially in areas where dry conditions prevailed. Peach yields were down 39% from those in 2004 (Illinois Agricultural Statistics Service, September 13). Drought conditions negatively impacted Christmas tree growers in two ways, causing brown patches to develop in existing trees and killing most recently planted trees and saplings. (Chicago Tribune, November 25) The drought also hurt hay and alfalfa crops, leading to a raise in prices for livestock feed (Farm Week, August 1b).

## **IMPACTS**

The drought and its expected impacts on the state's major crops, corn and soybeans, had major effects on the grain market. At the end of May crop prices were rising as awareness of the emerging drought developed (Chicago Tribune, May 29). By early July a very volatile "weather market" had developed with prices fluctuating from day-to-day as the weather shifted from hot and dry to occasional rains (Chicago Tribune, July 5). However, as the summer wore on and the regional dimensions of the drought area became well-defined as being largely within parts of Illinois, prices began to fall during August. This resulted because crop yields in the other Corn Belt states were predicted to be high, and the USDA announced the national production of corn and soybeans would be high (Chicago Tribune, August 13).

### **Economic Impacts**

Potentially poor yields in Illinois, but good yields elsewhere in the Corn Belt, spelled serious economic problems for Illinois farmers. They faced low yields and low crop prices. The flow of the Mississippi River was reduced sufficiently by August to affect barges carrying grain. Barge loadings had to be reduced, resulting in higher shipping costs (Champaign Gazette, August 11). Furthermore, other events were raising farm costs for energy and shipping. Hurricane Katrina did great damage on August 29 to grain elevators in the New Orleans area where 50% of all Illinois grain crops are handled for export, and the storm did immense damage to oil production facilities along the Gulf Coast. These two outcomes brought higher grain shipping costs and higher costs for fuel needed for grain drying and harvest. Experts reported that the 2005 crops were the most expensive ever (Farm Week, September 19) with average costs for corn at \$206 per acre and \$113 per acre for soybeans. Thus, experts predicted that the low yields, low prices, and higher costs would lead many Illinois farmers to store and not sell their crops.

What did the drought cost Illinois farmers? In mid-August the head of the Illinois Farm Bureau estimated that the loss to farmers would be \$2 billion, as measured from their 2004 incomes when yields set all-time record highs (Farm Week, August 21). Loss estimates issued later were less, with crop experts claiming losses would be slightly more than \$1 billion (Chicago Tribune, September 4). The U.S. Department of Agriculture announced on September 20 that the drought loss in Illinois would be \$1.3 billion (Champaign Gazette, September 21).

Given low prices, the 2005 production of corn in Illinois (1.73 billion bushels) and of soybeans (425 million bushels) translated into farm income that totaled \$5.626 billion for Illinois. This represented an average of \$75,618 per farm. The 2005 total income to Illinois farmers was 31 percent less (\$2.5 billion) than they received in 2004 when record high yields occurred. The 2005 total income was 5 percent (\$266 million) less than the average for 1994-2003. Thus, the 2005 conditions cost Illinois farmers \$34,000 in comparison to their 2004 income and was \$3,570 less than the average farm income based on 1994-2003.

Without the rains from the four tropical storms that each affected large parts of the state (Fig. 4), crop losses would have been much higher. Farmers in the southern half of Illinois greatly benefited from these rains as corn and soybean yields were well above average (Tables II and III).

The drought 2005 impacts had various effects on future activities. One such impact was a lowering of farm land prices (Farm Week, August 8b). The drought also limited the uptake of nitrogen fertilizer in many fields, and this meant that less fertilizer would need to be applied in 2006. Some crop experts felt that the successful winter wheat yields in 2005 would likely lead to a greater planting of wheat in 2006. The lower income and tight economic conditions on many farms would lead to reduced purchases of farm equipment. Major seed firms reported no loss of seed corn supplies for 2006.

### **Government Actions**

The issue of government assistance for Illinois farmers developed as the potentially serious impacts of the drought on Illinois crop yields became evident in June. In early July the Illinois Department of Agriculture began monitoring crop conditions in 51 counties for the development of a possible disaster declaration. To qualify for federal disaster assistance, a county has to have at least 30% production losses in one major crop. Farmers were advised to certify their crop acreage by July 15 to qualify themselves for inclusion in a disaster declaration or for federal crop insurance. In late June, the Governor activated the state's Drought Task Force, and it continued to meet during July and August to assess and report on the drought's status.

The Governor of Illinois decided in mid-July to request federal disaster assistance, and the federal Farm Service Agency (FSA) began assessing which counties were eligible. The FSA found that 101 counties qualified for disaster declarations, and the Governor formally requested federal aid in late July. The Illinois Treasurer also initiated a \$100 million drought relief program to provide low interest farm loans. (Farm Week, August 1a). By the end of August, 700 loans had been made totaling \$47 million. Approximately

65% of the Illinois corn and bean crops had been insured (Farm Week, August 15b). In late August 74,000 Illinois farms had projected drought-related crop losses greater than 30% (Farm Week, September 5).

Illinois' members of Congress all agreed they would push for federal aid for the drought, admitting that aid would be hard to obtain because the drought problem area was largely confined to one state—Illinois. To get the desired aid would likely require that Congress extend the 2003-2004 disaster assistance program legislation, slated to terminate on September 1, 2005. The advent of Hurricane Katrina with its huge losses along the Gulf Coast became an issue by September 1 that affected the potential for drought assistance to Illinois. As September wore on, Illinois' two senators pushed for a "drought relief plan" as a means for extending the 2003-2004 assistance legislation. Members of the House from Illinois offered three bills with different relief plans, revealing a need for a compromise. Political endeavors to get federal disaster funds for Illinois farmers went on hold during October and November. Some policy experts concluded that Congressional efforts to provide federal aid funds had ended when the above-average statewide corn and soybean yield values appeared in early October. However, in mid-December Congress was debating the dimensions of the \$453 billion defense spending bill that included several non-defense items like farm relief and relief for Hurricane Katrina. The Senate had inserted \$1.6 billion in the defense bill for farm relief resulting from droughts, floods, and hurricanes. However, the House refused to include the added farm relief funding, insisting that all relief funding (\$29 billion) should go to victims of Hurricane Katrina (Chicago Tribune, December 21). Illinois' two senators argued against the House position, but were told that Illinois' key House members went along with President Bush's wishes which were against funds for farm relief. House members further claimed that the farm assistance efforts of the Illinois senators were a political ploy to try to thwart other provisions in the defense bill. Essentially, federal disaster relief for Illinois farmers had become an issue caught up in political differences in Congress.

#### **Effects on Agribusinesses**

The drought and its impacts on crops also had impacts on certain agribusinesses. For example, John Deere, a major producer of farm equipment, reported in August that sales had declined by 3.5% because of the drought and the company's stock values fell by 11%, leading the company to cut production (Chicago Tribune, August 17). In contrast, major seed companies and fertilizer firms reported no impacts from the Illinois-centered drought. The impacts of the drought, and fears of its continuation into 2006, led to major sales of biotech corn varieties that were found to be drought resistant in 2005. Two seed firms reported that their triple strain varieties were sold out by December 1, 2005 (Farm Week, December 19). The lower flow on the Mississippi River reduced barge loads and this was costly to farmers and barge companies. One barge firm reported having lost \$300,000 due to smaller loads (Champaign Gazette, August 11).

The outcome for grain elevators was mixed with much grain assigned to storage. The high costs of crop production and shipping and low crop prices led many farmers to store their grain, a boost in income for some elevators. However, the inaccurate predictions of final yields created major crop storage problems at many elevators which partly occurred because many elevators had carried old corn during the summer, based on the predictions that the 2005 crop was going to be quite low. By late October, 97 million bushels of corn

were stored uncovered in piles on the ground (Farm Week, October 31) at considerable costs. Other factors affected the huge storage problem including the rapid harvest, high costs of grain shipping, and lack of barges and rail cars. Agricultural realtors were losers because the drought brought decreased land prices (Farm Week, August 8).

### **SUMMARY AND CONCLUSIONS**

Agricultural experts all agreed, from early June until late August, that the crop impacts of the 2005 growing season drought in Illinois were going to be serious, with sizable reductions in crop yields. Unexpectedly, the final corn and soybean yields over most of the state were at or above average levels. Experts then speculated that the few rains that did occur were not heavy but timely, and further claimed that improved crop genetics and farm practices made the crops more resilient to drought. Regardless, these factors were not detected nor realized by agricultural experts during the growing season, suggesting that the crop-weather relationships in use do not adequately define current weather-yield relationships.

An important and interesting weather aspect of the growing season drought of 2005 was the rainfall, mainly in the southern third of the state, from the unusually frequent passages of four tropical storms. These storms produced no damages and sufficient rainfall to bring major benefits to those parts of Illinois which enjoyed above average crop yields.

Clearly the predicted low crop yields issued during the growing season and the much higher final yields reflect crop-weather relationships different from those established using data from earlier years. Past studies have shown that dryness and above average temperatures, as experienced in 2005, would have resulted in well below average yields (Changnon and Winstanley, 2000). Yet, in 2005, Illinois had above average corn and bean yields, and the state's soybean yield of 47 bu/acre was the second highest on record.

The 2005 yield outcome was the third consecutive year when estimated and final crop yields in Illinois have widely differed. In 2003 and 2004, higher-than-expected crop yields occurred as a result of copious sunshine that created positive yield effects that went undetected by experts (Changnon and Hollinger, 2004; Changnon and Changnon, 2005). Collectively, the incorrect in-season yield estimates of 2003, 2004, and 2005 suggest that crop genetics and farming practices have changed dramatically and have altered the stresses of weather. Crops are also more responsive to sunshine and crops are now capable of producing yields at higher levels than prior crop-weather studies have shown. The poor yield predictions in 2005 had serious impacts, including the government's extensive and fruitless efforts to get financial aid, and on grain elevators which suffered high costs for storing surplus grain unexpected from the yield forecasts.

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Figure 1. Monthly percent of average precipitation for each of Illinois' nine climate divisions, March-September 2005.

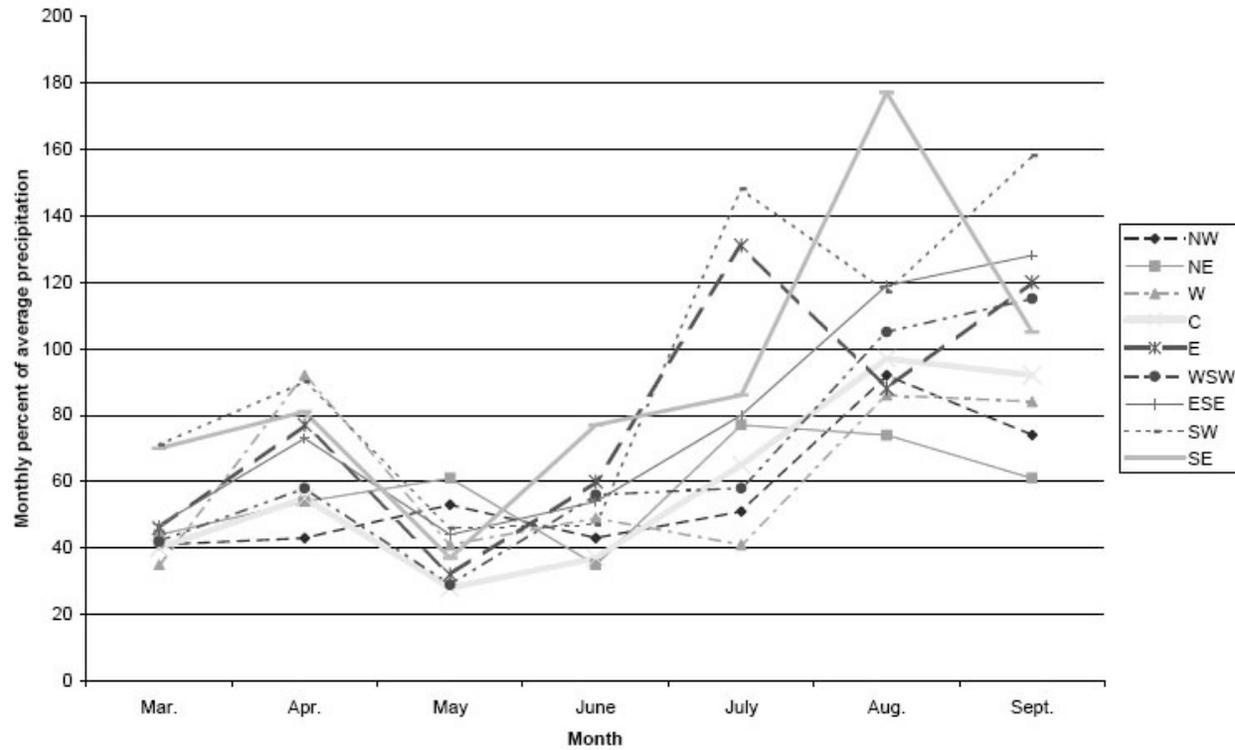


Figure 2. Monthly departure from average temperature (°F) for each of Illinois' nine climate divisions, March-September 2005.

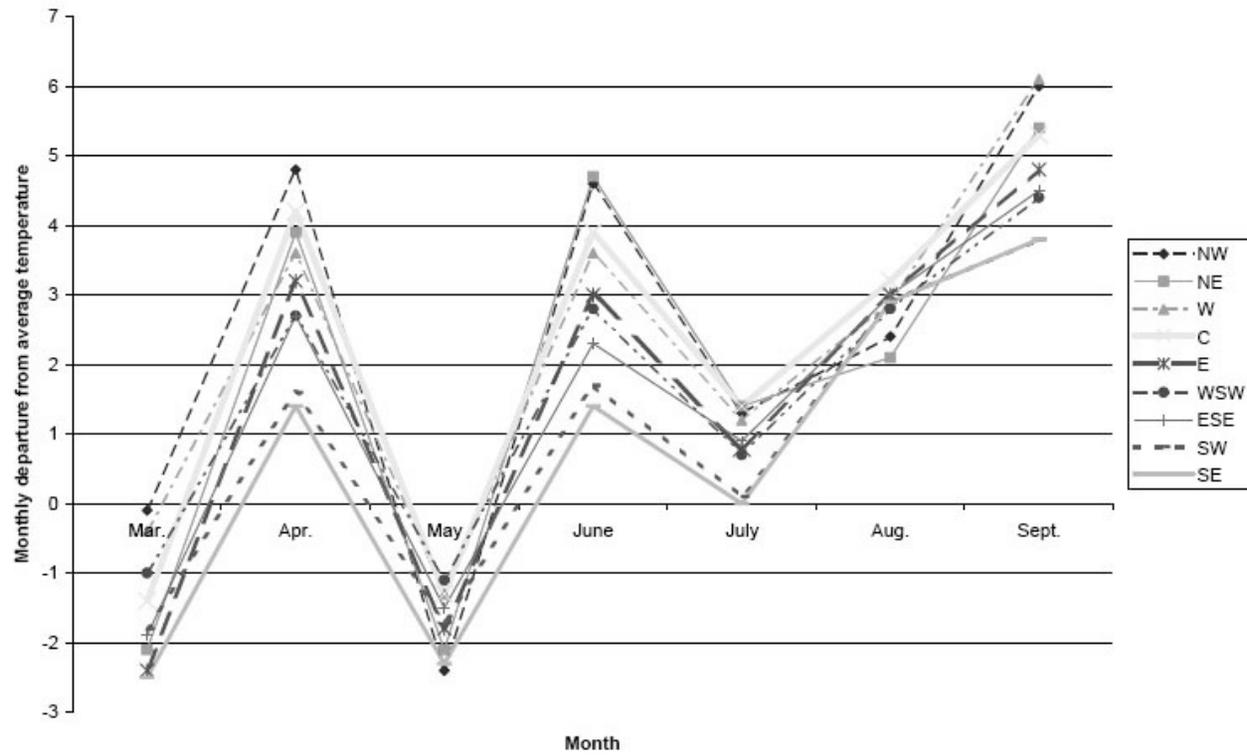


Figure 3. Drought conditions on August 23, 2005, as presented on the U.S. Drought Monitor (USDA).

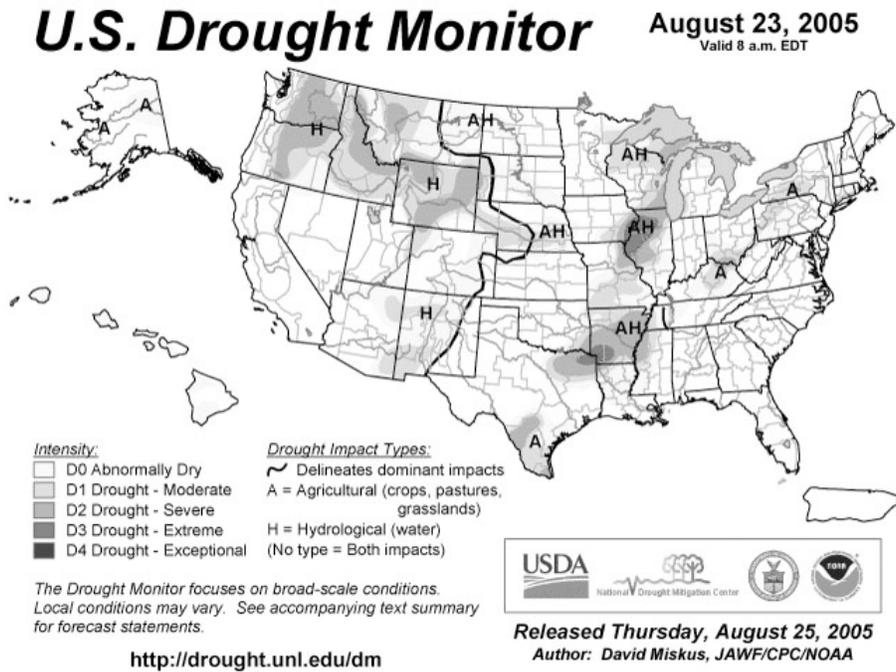


Figure 4. Rainfall for June-September 2005 derived from four tropical storms.

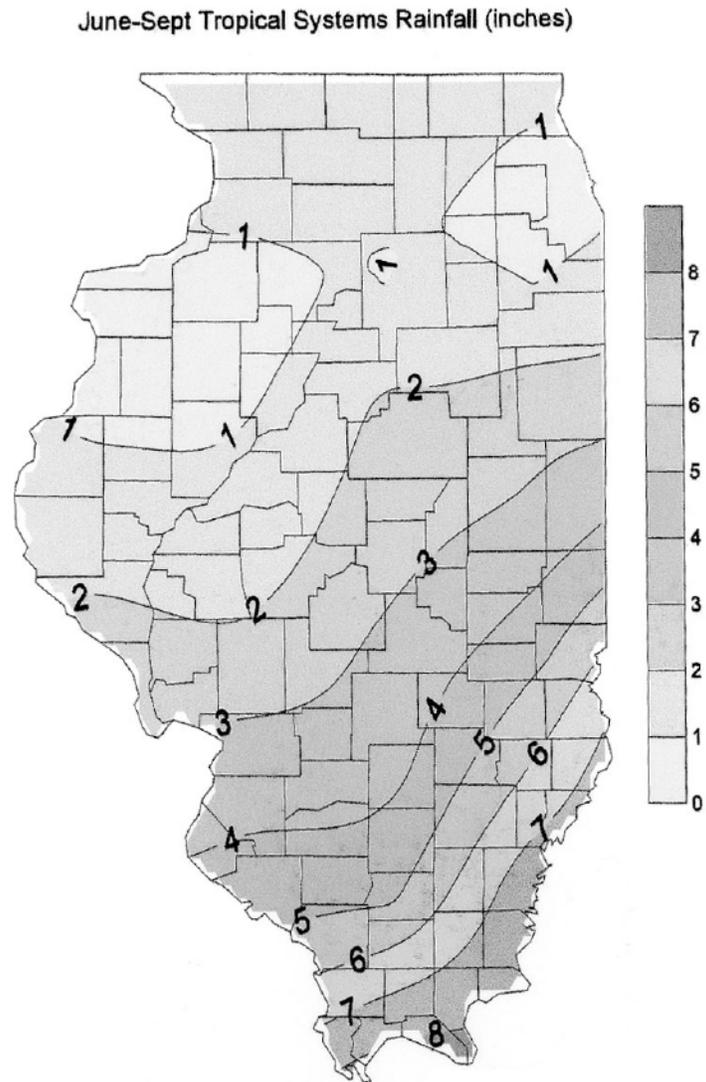


Table I. The status of Illinois corn and soybean crops during 2005. The amount of each crop in each category is expressed in percentages of the total crop in Illinois.

Crop	Date	Excellent	Good	Fair	Poor	Very Poor
Corn	June 5	6%	49%	34%	9%	2%
Corn	July 2	3%	29%	40%	20%	8%
Corn	August 7	0%	12%	27%	32%	29%
Soybeans	June 5	5%	50%	33%	10%	2%
Soybeans	July 2	2%	31%	43%	17%	7%
Soybeans	August 7	1%	18%	40%	25%	16%

Table II. Regional corn yields in Illinois for 2004, 2005, averages for 1994-2003, and the difference between the average and the 2005 value.

	Crop Districts								
	NW	NE	W	C	E	WSW	ESE	SW	SE
2005	140	129	141	146	158	151	139	133	130
2004	184	174	192	186	180	186	175	158	158
Average	149	143	149	154	144	147	130	110	110
Difference	-9	-14	-8	-8	+14	+4	+9	+23	+20

Table III. Regional soybean yields in Illinois for 2004, 2005, averages for 1994-2003, and the difference between the average and the 2005 value.

	Crop Districts								
	NW	NE	W	C	E	WSW	ESE	SW	SE
2005	48	44	47	51	51	46	46	42	44
2004	52	51	53	54	52	51	50	44	44
Average	46	43	46	47	45	43	39	34	34
Difference	+2	+1	+1	+4	+6	+3	+7	+8	+10