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Early Prospects for 2009 Corn Yields in Illinois, Indiana, and Iowa

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INTRODUCTION

The USDA's first forecast of the potential size of the 2009 U.S. corn crop was released on May 12 (USDA/WASDE, 2009). That forecast was based on: 1) acreage expected to be harvested for grain, which is a function of planting intentions revealed in the March 2009 *Prospective Plantings* report and the historical relationship between acreage planted for all purposes and acreage harvested for grain, and 2) projected yield, which USDA defined as "… the simple linear trend of the national average yield for 1990-2008 adjusted for 2009 planting progress." The projected yield was 155.4 bushels per acre, which reflected a 1.5 bushel penalty for the slow pace of planting progress in the eastern Corn Belt. The 2009 production forecast was 12.09 billion bushels.

Extended planting delays were experienced in a number of states, particularly in Illinois, Indiana, Kentucky, and North Dakota. In contrast, planting progress was at a more normal pace in the large corn producing states of Iowa, Minnesota, and Nebraska. Nationally, 93 percent of the crop was planted as of May 31, 2009, compared to an average of 97 percent for the previous 5 years. While planting progress eventually caught up to the average pace, interpolation of weekly planting progress data suggested that about 30 percent of the U.S. acreage was planted after May 20, a proportion exceeded only three times in the last twenty years (1993, 1995, and 1996). The general lateness of planting and the large discrepancy in planting progress by region raises additional questions about the potential U.S. average corn yield in 2009.

The purpose of this brief is to evaluate 2009 yield potential for corn in Illinois, Indiana, and Iowa using a previously developed crop weather model that estimates the impact of technology (trend), state average monthly weather variables, and portion of the crop planted late on state average yield (Irwin, Good, and Tannura, 2008). The model is first re-estimated to better capture the influence of April precipitation and late planting and then used to analyze yield prospects in each of the three states for 2009. First, projections are made based on actual weather through April, the portion of the crop planted after May 20, and the probability that summer weather conditions reflect the actual distribution of summer conditions from 1960 through 2008. This is referred to as the "average" forecast. Projections are also made based on "poor" and "good" summer weather conditions. These three scenario forecasts are then compared to the trend yield for 2009 and some preliminary thoughts of yield potential in each of the three states are presented.

Finally, some discussion of the potential U.S. average corn yield in 2009 is provided.

PLANTING DATES AND YIELD

Among the many factors, other than weather, that can influence corn yields, planting date has been demonstrated as important (Egli, 2008). There are, however, two aspects of planting date that may be important for yields. One is the trend toward earlier planting that is thought to contribute to the overall trend increase in yields. Figure 1 illustrates the trend toward earlier planting of corn in Illinois. Compared to 1965, for example, corn planting in Illinois in 2005 was started and completed about two weeks earlier.[1]

The second aspect of the planting date influence on yields is the timeliness of planting in a given year. Agronomic research reveals that "late" planting in a given year generally results in lower yields than timely planting (Nafziger, 2008; Nielsen, 2008). Figure 2 is representative of results from agronomic experiments investigating the effect of planting date on corn yields. In central Illinois, for example, average corn yields are not found to be substantially different for planting dates ranging from early April to early May. Yields, however, generally decline at an accelerating rate for planting dates after early May. For a recent and concise discussion of some of the physiological and agronomic factors that contribute to yield penalties for late planted corn see Nafziger (2009).

Planting date results from agronomic experiments are widely used as a guide to planting decisions by farmers. This is sensible for individual farmers in a given year because the experiments carefully isolate planting date impacts by holding other production factors constant. However, experimental results do not necessarily provide good estimates of actual planting date impacts for large areas, such as states or regions. The first reason is that planting in any given year generally is spread over several weeks, with some acres planted in a timely fashion and some planted late. The second reason is that spring and summer growing season weather varies substantially from year-to-year. Nielsen (2008) notes that yield loss estimates from agronomic experiments are relative to the maximum yield possible in a given year. The variation in maximum yield due to variation in growing season weather can easily swamp the impact of planting delays.

An alternative approach is to partition the effect of planting date on state average yields over time using a crop weather model. This is also challenging due to uncertainties about the specification of planting date variables, and consequently, few attempts have been made to estimate the impact of planting date on state average yields. Kucharick (2008) recently investigated the relationship between state average corn yields, planting dates, and monthly average weather variables over 1979 through 2005 for 12 Corn Belt states. Results were mixed, but generally showed that earlier planting explained a significant proportion of corn yield trends in the western and northern Corn Belt. Kucharick did not delineate the impact of earlier planting dates over time versus late planting in any given year. In addition, the study used a relatively short sample period, projected planting progress for dates before actual planting progress data were available in some years, and imposed a linear relationship between yield and precipitation variables.

STATE LEVEL PLANTING PROGRESS

The U.S. Department of Agriculture (USDA) provides a weekly assessment of cumulative state corn planting progress, expressed as the percentage of the crop planted, in the *Crop Progress* report.

[1] See Irwin, Good, and Tannura (2008) for further information on trends in planting dates since 1960 for Illinois, Indiana, and Iowa.

Planting progress data for 1979 through 2009 are available at the USDA's Quick Stats web site.[2] For years before 1979, planting progress information is available in the *Weekly Weather and Crop Reports* from individual states. Since 1979, weekly planting progress has been reported for all states as of the week ended on Sunday. Prior to that, the week-ending date was Monday for Illinois and Iowa. The week ending date for Indiana was Saturday for 1960-1966, Friday for 1967-1976, and Sunday for 1977-1978.

Measuring the magnitude of late planting is complicated by three issues. The first is the changing yield penalty as planting dates become progressively later. Based on the response curve presented in Figure 2, separate variables representing the percentage of the crop planted in each 10-day interval could be specified. This would likely lead to over-parameterized models and imprecise parameter estimates. Estimation would be further complicated by the positive correlation between such variables. The second issue is that the definition of "lateness" has undoubtedly changed over the sample period. It is reasonable to assume that the trend towards earlier planting dates goes hand-in-hand with changing experimental evidence on optimal planting dates. The third issue is that planting date impacts are already represented to some degree in previous crop weather models via May precipitation variables.

Some of these issues were addressed in the crop weather models developed a year ago by Irwin, Good, and Tannura (2008). A two-pronged approach was adopted to represent late plantings in each year of the sample. The first part of the approach was to specify May precipitation in quadratic form. This would allow the relationship between May precipitation and corn yields to exhibit declining yields if too little or too much precipitation is received. The second part of the approach was to include a variable in the crop weather models to represent corn planted towards the end of the windows represented in Figures 2. An issue in specifying this variable was that the definition of "late" needed to be adjusted over the sample period. What was considered late based on agronomic experiments in 2007 may not have been late in 1960.

Irwin, Good, and Tannura (2008) consulted *Illinois Agronomy Handbooks* going back to 1968 with regard to changing agronomic recommendations for corn planting dates. The *Handbooks* always emphasized "early" planting of corn in Illinois, with the definition changing over time. The most notable change occurred in the early 1980s, when recommendations focused on *completing* corn planting by early May. Previously the focus was on *starting* to plant corn by mid-April. Based on this information, the late planting variable was defined as the percentage planted after May 30th over 1960-1985 and after May 20th over 1986-2007.

The late planting variable for each state is plotted in Figure 3 over 1960-2009. Observations for 2008 and 2009 are based on the same definitions used earlier by Irwin, Good, and Tannura (2008). There is almost no trend in any of the late planting variables, indicating that the specification of "lateness" remains stable over time. The charts also indicate that the percentage of corn planted late is low in most years and a handful of years have very high values. The historically large magnitude of planting delays in the eastern Corn Belt during 2009 is highlighted in the plots for Illinois and Indiana. The 62 percent of corn planted after May 20th in Illinois was only exceeded in 1995, when 63 percent of the crop was planted late. Similarly, the 63 percent of corn planted after May 20th in Indiana has only been exceeded twice since 1960 (in 1996 and 2002). With only 7 percent planted after May 20th this year, the level of

[2] See http://www.nass.usda.gov/QuickStats.

late planting in Iowa was actually slightly below average.

REVISED CROP WEATHER MODELS

The crop weather models presented by Irwin, Good, and Tannura (2008) were re-estimated using state-average corn yields in Illinois, Indiana, and Iowa over 1960-2008.[3] In these earlier models, a linear time trend variable was used as a proxy for technology. Weather variables included total pre-season precipitation (September-April), May through August monthly precipitation, and June through August monthly average temperature. Pre-season precipitation and all temperature variables were included in linear form, while May through August precipitation was included in quadratic form. The late planting variable discussed in the previous section was also included in linear form.

Those models explained about 95 percent of the annual variation in state average corn yields from 1960 through 2007. However, the late planting and May precipitation variables were highly correlated, which created estimation problems for both variables. Specifically, May precipitation was not a statistically significant variable in any of the states and the late planting variable was only significant in Iowa. In addition, the June temperature variable was not statistically significant in any state and preseason precipitation was only significant in Iowa.

Several changes were made to the crop-weather model in an effort to improve yield forecasts while at the same time maintaining a relatively simple specification. The revised model retains the same trend variable, but May precipitation is dropped from the model in order to address problems created by the correlation between lateness of planting and May precipitation. The late planting variable from the previous version is retained.[4] The preseason precipitation variable is now defined as total precipitation from September through March, rather than September through April, and is also entered in quadratic form. April precipitation is added to the model and the May and June temperature variables are deleted. The crop weather models estimated over 1960-2008 are presented in Table 1.

In the revised model, each one percent of the crop planted late reduces the state average corn yield by 0.29 bushels in Illinois, 0.18 bushels in Indiana, and 0.38 bushels in Iowa. The late planting coefficient estimates in the revised model are more consistent with planting trial results than our results from a year ago. First, the coefficients are now statistically significant in all three states, consistent with experimental trials that show substantial penalties for late planting in all three states. Second, the magnitude of late planting effects implied by the coefficients indicates that step-wise planting trial results, such as those found in Figure 2, are approximated reasonably well. For example, assume that 25% of the Illinois corn crop is planted from May 1st-10th, 25% from May 11th-20th, and 50% from May 21st-May 30th. The yield penalty estimated by the crop weather model for Illinois would be 14.5 bushels, compared to a yield penalty of 18.9 bushels based on the planting trial results in Figure 2.

April precipitation has a relatively large and statistically significant impact on average

[3] See Tannura, Irwin, and Good (2008a) for a detailed discussion of the specification and estimation of crop weather models.

[4] The late planting variable was also specified as the percentage planted after May 20th over 1960-1985 and after May 10th over 1986-2007. This version of the late planting variable resulted in slightly worse model fits. Both versions of the late planting variable were also considered in quadratic form, with no improvement in model performance.

yields in all three states. This result is somewhat surprising and the agronomic explanation of the result is incomplete. One possibility is that April precipitation is an important determinant of sub-soil moisture at the start of the growing season. The effect of other weather variables is similar to those estimated in the previous version of the model.[5] The estimated impact of each variable on corn yield in the three states is presented in Figure 4. The impacts are plotted for the historical range of each variable across the three states and the X's indicate the average level of the variable over 1960-2008.

MODEL PROJECTIONS FOR 2009

As a starting point, 2009 trend yields for each state are calculated. This calculation is not as straightforward as it first appears. Conventionally, trend yield is calculated from the best linear fit of historical actual yields on a time trend variable (1,2,3,…). For example, the best linear fit of actual yields in Illinois from 1960 through 2008 results in a trend calculation for 2009 of 163.1 bushels. This methodology results in a slight underestimate of trend yield due to the asymmetric effect of weather on actual yields. That is, poor weather reduces yields more than good weather improves yields so that the impact of technology (trend) is underestimated due to sharp reductions in yield from "poor weather" years, such as 1974, 1983, 1988, and 1993 (Swanson and Nyankori, 1979; Tannura, Irwin, and Good, 2008a).

An alternative approach to calculating trend yield for 2009 is to impose on the crop weather model the assumption of average weather over the past 49 years along with the average portion of the crop planted late over that period. That approach results in a calculation of 174.9 bushels for Illinois in 2009. But, this calculation overstates trend yield, again due to the asymmetric effect of weather on yields. That is, the assumption of average weather does not accurately reflect the large negative yield effects of poor weather relative to the smaller positive effects of good weather.

A third approach, and the one adopted here, is based on the assumption that the actual distributions of weather conditions and late planting over the past 49 years are representative of the distributions expected for 2009. That is, the model results are computed for each of the 49 years in the data series, assuming 2009 production technology, and the model results are averaged to represent the trend yield for 2009. That calculation is 166.3 bushels for Illinois, 156.8 bushels for Indiana, and 167.9 bushels for Iowa. These calculations can be viewed as the most likely yield outcomes (in terms of 2009 technology) if the conditions in each year from 1949 through 2008 had an equal probability of occurring in 2009.

Yield forecasts also are made for 2009 using the crop weather model under poor and good weather scenarios. All three scenarios—average, poor, and good—incorporate actual precipitation from September 2008 through April 2009 and the percent of the crop planted late in each state, but reflect different weather scenarios from June through August. Average weather is reflected by computing model yield predictions for actual summer weather conditions in each year from 1960 through 2008 and averaging the results. This is different than applying the model assuming average summer weather conditions of the past 49 years. The latter calculation would overstate yield prospects for the reasons

[5] Following Tannura, Irwin, and Good (2008b), the possibility of a change in the trend rate of growth in corn yield was investigated for the revised models. Unknown breakpoint tests do not provide evidence of a statistically significant change in trend in any of the three states during the sample period. Additional tests that restrict the trend breakpoint to recent years (e.g., 2003) indicate small and insignificant increases in trend (about 0.1 bushels per year) for Illinois and Indiana and a small and significant increase in trend (about 0.2 bushels per year) for Iowa.

discussed above relative to trend yield calculations.

The poor weather scenario reflects the average of the model yield predictions for the ten most unfavorable summer weather conditions from 1960 through 2008. The good weather scenario reflects the average of the model yield predictions for the ten most favorable summer weather conditions from 1960 through 2008. Note that favorable and unfavorable weather years in the poor and good scenarios are not directly identified based on actual weather conditions. Instead, those years are identified by applying the model to each year from 1960 through 2008 assuming 2009 production technology, actual weather through April 2009, and the portion of the crop planted late in 2009. The 10 lowest yield forecasts are averaged to produce the poor weather forecast and the 10 highest yield forecasts are averaged to produce the good weather forecast. This is akin to using the model projections for each year as a weather index.

Yield forecasts are presented in Table 2. The first point of importance is that trend yield calculations for each state are relatively low compared to the actual yields of 2007 and 2008 in Illinois and Iowa (Figure 5), suggesting that market participants may have too high of a starting point in forming expectations about yield potential in 2009 if data for recent years is over-weighted.

The second point is that late planting in Illinois and Indiana is likely to have reduced yield potential to well below trend value unless summer weather is favorable in those states. The average weather scenario (as defined earlier) results in yield forecasts 11 and 5.1 bushels below trend in Illinois and Indiana, respectively. The good weather scenario results in above trend forecasts for both states. However, the forecast of 171.6 bushels in Illinois is 5.4 bushels below the average of the past two years. The good weather forecast for Indiana is 7.2 bushels above the average of the past two years.

There is, of course, great interest in the specific impact of planting progress on corn yields in 2009. Estimated impacts illustrated in Figure 6 are very large (and negative) for Illinois and Indiana due to the extreme lateness of planting. There is a small positive impact from very timely planting in Iowa. It should be noted that the model specification makes these impacts permanent regardless of summer weather. Yields would be expected to be lower in Illinois and Indiana under all three weather scenarios than would be experienced had planting been more timely. The actual level of preseason and April precipitation this year is expected to have a positive impact on yield potential, particularly in Iowa.

The third point is that weather conditions to date and two of the three alternative summer weather scenarios considered point to a high average yield in Iowa. The average summer weather scenario results in a yield forecast 6.8 bushels above trend value and 3.7 bushels above the average yield of the past two years. Only a poor summer weather scenario would be expected to reduce the state average yield below trend value.

At this juncture, we anticipate that the 2009 average yield in Illinois and Indiana will likely be below both trend value and the average of the past two years, perhaps well below in Illinois. Conversely, it appears there is a reasonably high probability that the Iowa state average yield will be above both trend and the average of the past two years.

What are the implications for U.S. average yield prospects? It appears that Illinois and Iowa yield prospects reflect the extremes of yield potential relative to trend in 2009. Planting delays of lesser severity than in Illinois (as revealed in weekly estimates of the percent of the crop emerged) were experienced in Indiana, Kentucky, Michigan, Missouri, North Dakota, and Ohio. Conversely, minimal delays were experienced in Kansas, Nebraska, Minnesota, and South Dakota.

In assessing U.S. yield prospects for corn, the starting point is the appropriate trend yield calculation in 2009. Ideally, trend value could be calculated for each state in the same fashion as was done here for the three states (equal chances that 2009 summer weather would replicate one of the past 49 years) and the results weighted to form a national trend. Instead, most analysts use a trend of actual yields over a specific time period to calculate trend yield. Such a calculation generally underestimates trend yield due to the asymmetry of weather impacts as described earlier. In addition, such calculations can be biased by using an inappropriate time period. Many use a shorter time period than the 49 years we use here in order to capture an increasing trend thought to be occurring in more recent years. Based on application of the crop weather models for Illinois, Indiana, and Iowa, we see evidence of, at most, only a very small increase in trend in recent years (see footnote 4). The trend of actual yields over a recent short time period may actually overstate trend for 2009 due to the relative infrequency of widespread poor weather in recent years.

A simple linear trend calculation for the U.S. corn yield in 2009 based on actual yields for the period 1960 through 2008 is 152.8 bushels. Lacking any better information, we adjusted this simple linear trend calculation for the U.S. based on the observed bias in the simple linear trend estimates for Illinois, Indiana, and Iowa. Simple linear trend coefficients for these states were on average 0.08 bushels per year smaller than the corresponding estimates from the crop weather models. We assume that the true bias at the national level would only be half of this value because the impact of state level weather extremes would be dampened at the national level. This results in a 2.1 bushel upward adjustment (0.04 bushels/year X 50 years) in the U.S. trend yield to 154.9 bushels.

Since crop weather forecasts have only been developed for Illinois, Indiana, and Iowa, we follow a revised version of the procedure developed by Irwin, Good, and Tannura (2008) for projecting U.S. yields under the three weather scenarios. The first step is to calculate an acreage-weighted average of the three state forecasts, which is shown in Table 2. Irwin, Good, and Tannura (2008) used a simple average of the three state forecasts. The second step is to adjust the three-state average by the average ratio of the three-state weighted-average yield to national average yield over the last 10 years. Since Illinois, Indiana, and Iowa typically represent at least 40% of U.S. production this ratio is fairly stable and averaged 1.096 over the last decade. As an example of the adjustment procedure consider the scenario of average summer weather. The weighted-average of the three state yield forecasts is 162.9 bushels. Divided by 1.096, that average projects to a U.S. average yield of 148.6 bushels.

The size of the 2009 crop will also depend on the magnitude of acreage harvested for grain. Delayed corn planting in Illinois and Indiana is expected to result in some intended corn acres not planted at all or switched to soybeans. If half of the unplanted corn acreage in Illinois and Indiana at the end of May fall into one of those categories, planted acreage would be about 1.7 million less than indicated in March. Using the USDA planting intentions estimate of 85 million acres and acreage harvested for grain 7.2 million less than planted, such a reduction would point to harvested acreage of about 76.1 million acres in 2009. Table 2 shows production forecasts based on harvested acreage of 76.1 million and alternative yield projections. The yield forecast based on average summer weather conditions points to a crop of only 11.3 billion bushels. That compares to nearly 11.8 billion bushels under the trend yield scenario and 12.05 billion under the scenario (not presented) of trend yield and acreage near intentions.

CONCLUDING THOUGHTS

A yield forecast that reflected the current forecast of summer weather also could have been included in the analysis. That was not done because the outlook for July and August is not particularly reliable and the current National Weather Service outlook for June suggests about equal chances of normal, good, and poor weather in major producing areas. Using such a forecast would give results very similar to our average weather scenario. We do, however, suggest caution in the application of the specific forecasts from the crop weather model. The forecast errors of previously developed models were relatively large and that is likely the case for the current specification. Standard errors of the forecasts at this point in the growing season could easily exceed 15 bushels per acre. Nonetheless, combined with informed judgment and other information, such as USDA weekly reports of crop conditions, the models can be useful in forming production expectations. During July 2008, for example, in the midst of widespread concerns about growing conditions, our analysis utilizing crop weather models and crop condition reports concluded "A U.S. corn crop near 12 billion bushels and a soybean crop near 3.1 billion now appear most likely." The 2008 corn crop was 12.1 billion bushels, but the 2008 soybean crop turned out to be smaller (2.9 billion bushels) even though acreage exceeded intentions. The U.S. average yield was less than expected due to some unfavorable August weather.

We will continue to update the 2009 corn yield and production forecasts as the season progresses. Actual June precipitation levels and forecasts for July weather will be used in the crop weather models to update forecasts in early July. In addition, crop condition reports will be used to augment model yield results and the June USDA *Acreage* report will be used to update production forecasts. Similar updates will be provided in early August and early September.

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Table 1. Regression Estimates of Crop Weather Models for Corn Yield in Illinois, Indiana, and Iowa, 1960 - 2008

	Coefficient Estimates					
Independent Variable or Statistic	Illinois		Indiana		Iowa	
Constant	261.05	***	227.49	***	228.17	***
	(3.76)		(3.65)		(3.83)	
Annual Time Trend	1.90	***	1.73	***	2.01	***
	(23.74)		(19.00)		(22.77)	
Late Planting	-0.29	**	-0.18	***	-0.38	***
	-(3.21)		-(2.80)		-(3.16)	
Preseason Precipitation	1.32		3.36		6.48	**
	(0.44)		(1.17)		(2.11)	
Preseason Precipitation^2	-0.02		-0.07		-0.21	*
	-(0.23)		-(1.06)		-(1.83)	
April Precipitation	13.21	**	9.58	**	12.05	**
	(2.37)		(2.04)		(2.40)	
April Precipitation^2	-1.42	**	-1.04	*	-1.45	**
	-(2.07)		-(1.78)		-(2.09)	
June Precipitation	12.46	***	14.41	***	9.17	**
	(3.07)		(3.81)		(2.45)	
June Precipitation^2	-1.34	***	-1.50	**	-0.80	**
	-(3.07)		-(3.46)		-(2.28)	
July Precipitation	19.97	**	15.62	***	17.41	***
	(3.38)		(4.54)		(6.55)	
July Precipitation^2	-1.77	**	-1.25	***	-1.66	***
	-(2.66)		-(3.73)		-(6.36)	
August Precipitation	0.93		10.69	*	0.60	
	(0.17)		(1.84)		(0.22)	
August Precipitation^2	0.00		-1.24	*	0.03	
	(0.00)		-(1.73)		(0.12)	
July Temperature	-1.75	**	-2.04	***	-2.16	***
	-(2.46)		-(2.97)		-(3.40)	
August Temperature	-2.42	***	-2.13	***	-1.85	***
	-(4.62)		-(3.89)		-(3.56)	
R^2	0.96		0.95		0.96	
Standard Error (bu./acre)	7.30		7.42		7.74	
Regression F-statistic	54.17	***	44.95	***	54.39	***

Note: The figures in parantheses are t-statistics. One, two, and three stars denote statistical significance at the 10%, 5%, and 1% levels, respectively. Monthly precipitation variables are stated in inches and monthly temperature variables are stated in degrees Farenheit. Preseason precipitation is the sum of precipitation over September (previous crop year) through March (current crop year). Late planting is measured as the % planted after May 30th from 1960-1985 and after May 20th from 1986-2008.

Table 2. Alternative Forecasts of 2009 Corn Yield in Illinois, Indiana, Iowa, and 2009 U.S. Corn Yield and Production

		June-August Weather		
	Trend	Average	Poor	Good
Panel A. State Yield Forecasts				
Illinois (bu./acre)	166.3	155.3	133.8	171.6
Indiana (bu./acre)	156.8	151.7	131.8	164.2
Iowa (bu./acre)	167.9	174.7	157.1	187.0
3-State Average (bu./acre)	NA	162.9	143.3	176.8
Panel B. U.S. Forecasts				
Yield (bu./acre)	154.9	148.6	130.7	161.3
Production (mil.bu.)	11,784	11,307	9,950	12,272

Notes: NA denotes 'not applicable.' See the text for a detailed explanation of each state yield forecast. The 3-state average forecasts are weighted by planted acreage for each state as reported in USDA's March 2009 *Prospective Plantings* report. U.S. production forecasts for 2009 assume 83.3 million planted and 76.1 million harvested acres, respectively.

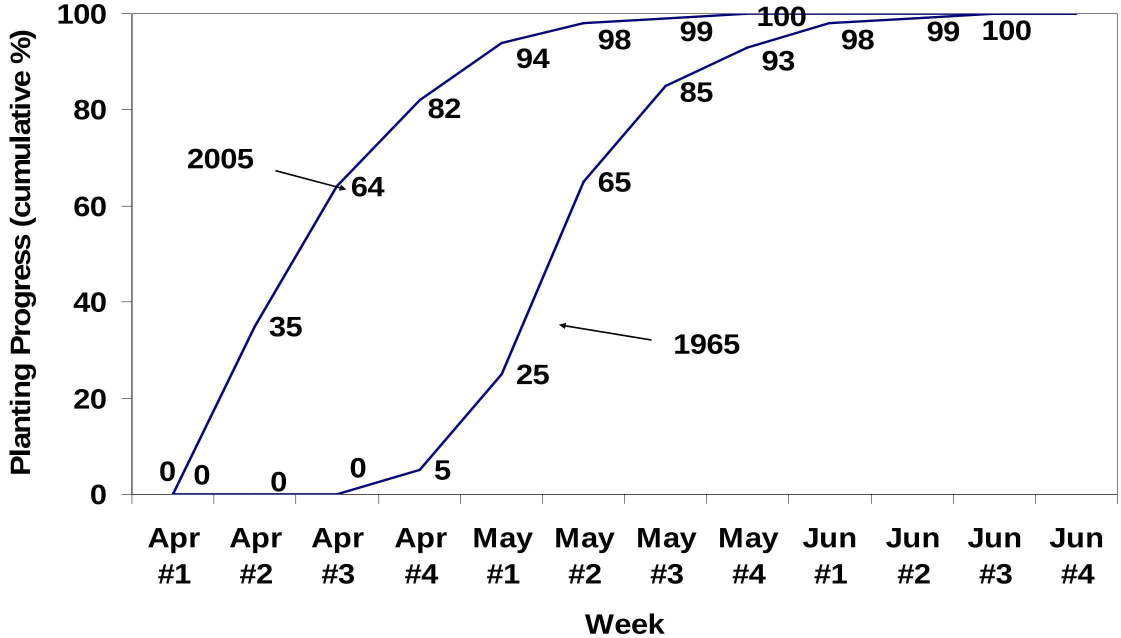

Figure 1. Comparison of Illinois Corn Planting Progress in 1965 and 2005

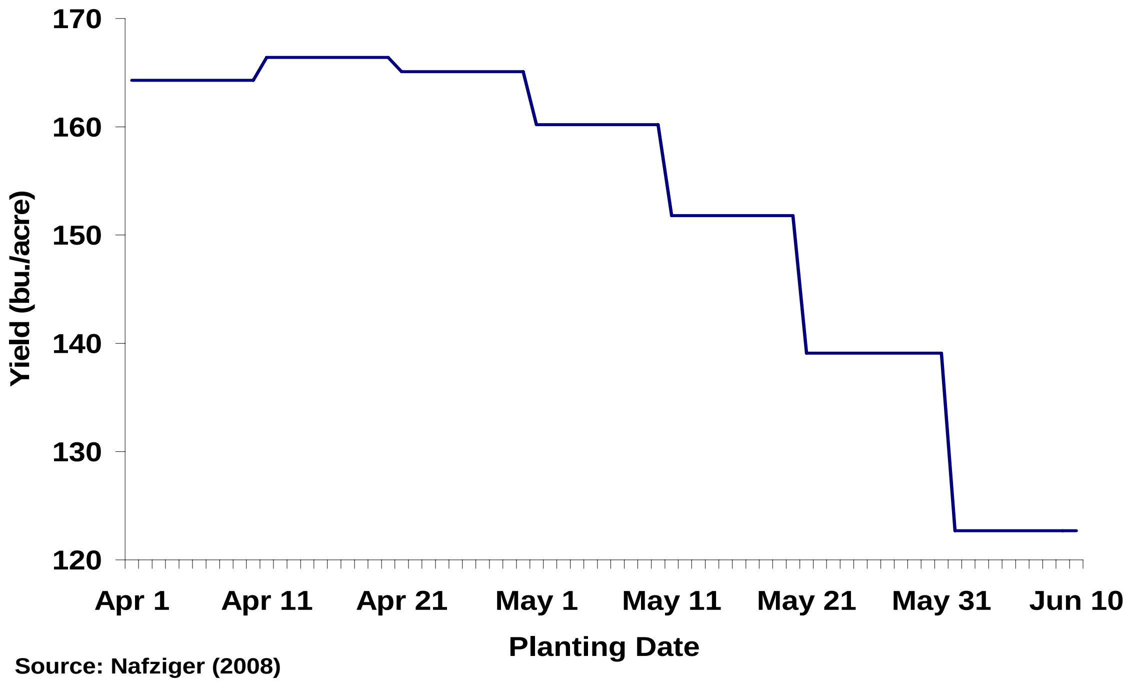

Figure 2. Response of Corn Yield in Central Illinois to Planting Date

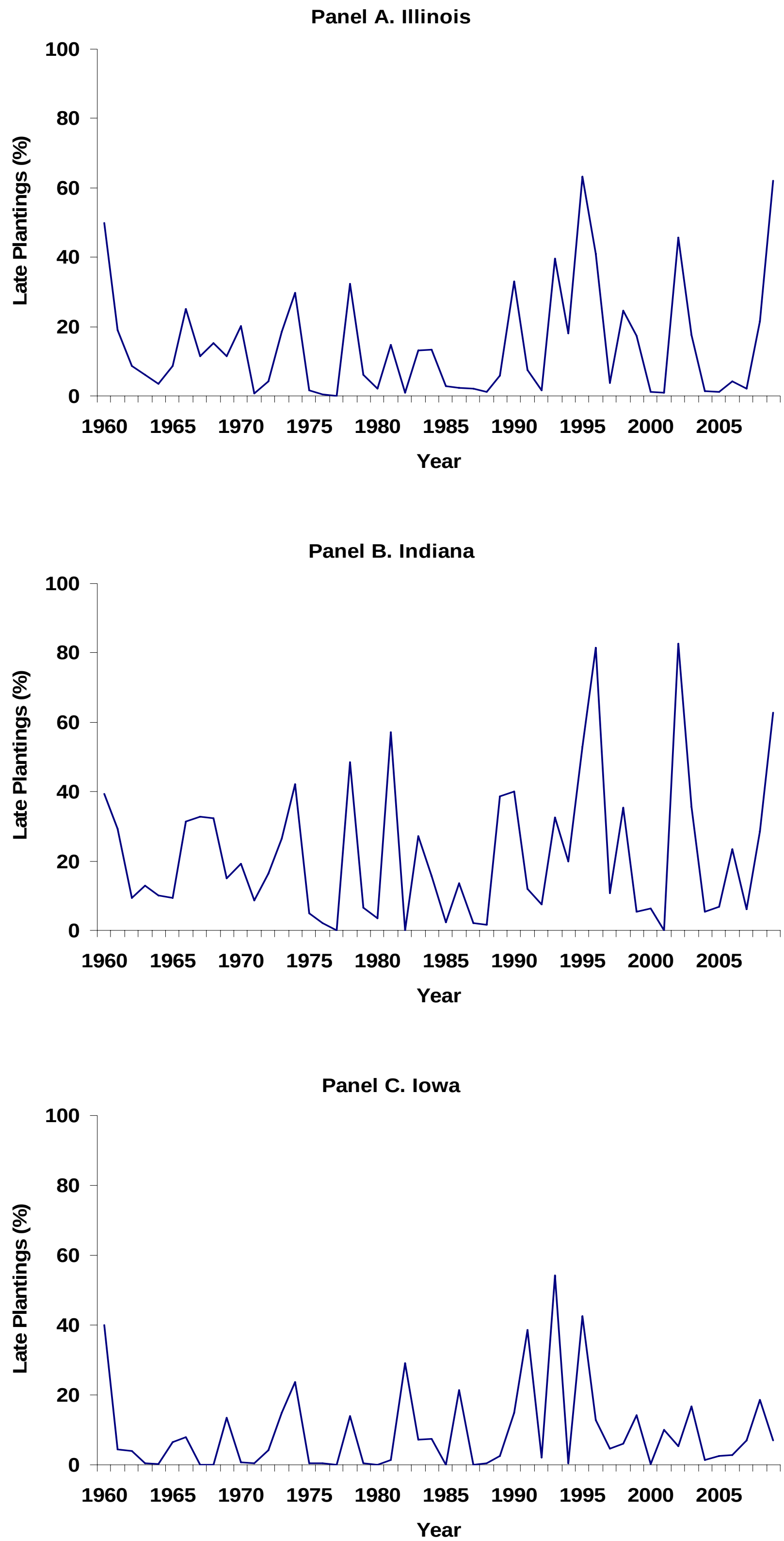

Figure 3. Proportion of Corn Planted after May 30th from 1960 - 1985 and after May 20th from 1986 - 2009 in Illinois, Indiana, and Iowa

Note: The X's indicate average values over 1960-2008.

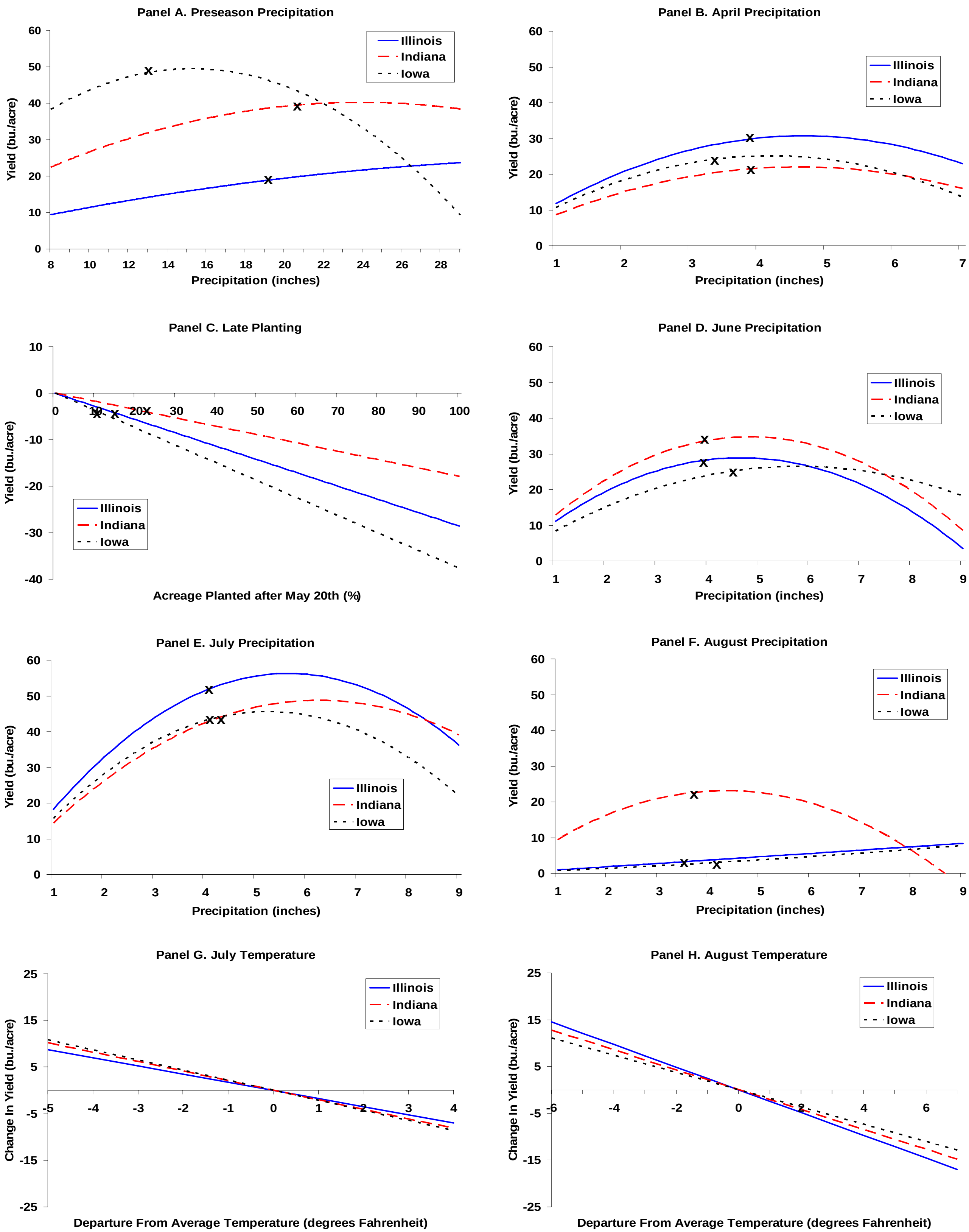

Figure 4. Estimated Impacts of Weather and Late Planting Variables on Corn Yield in Illinois, Indiana, and Iowa, 1960-2008

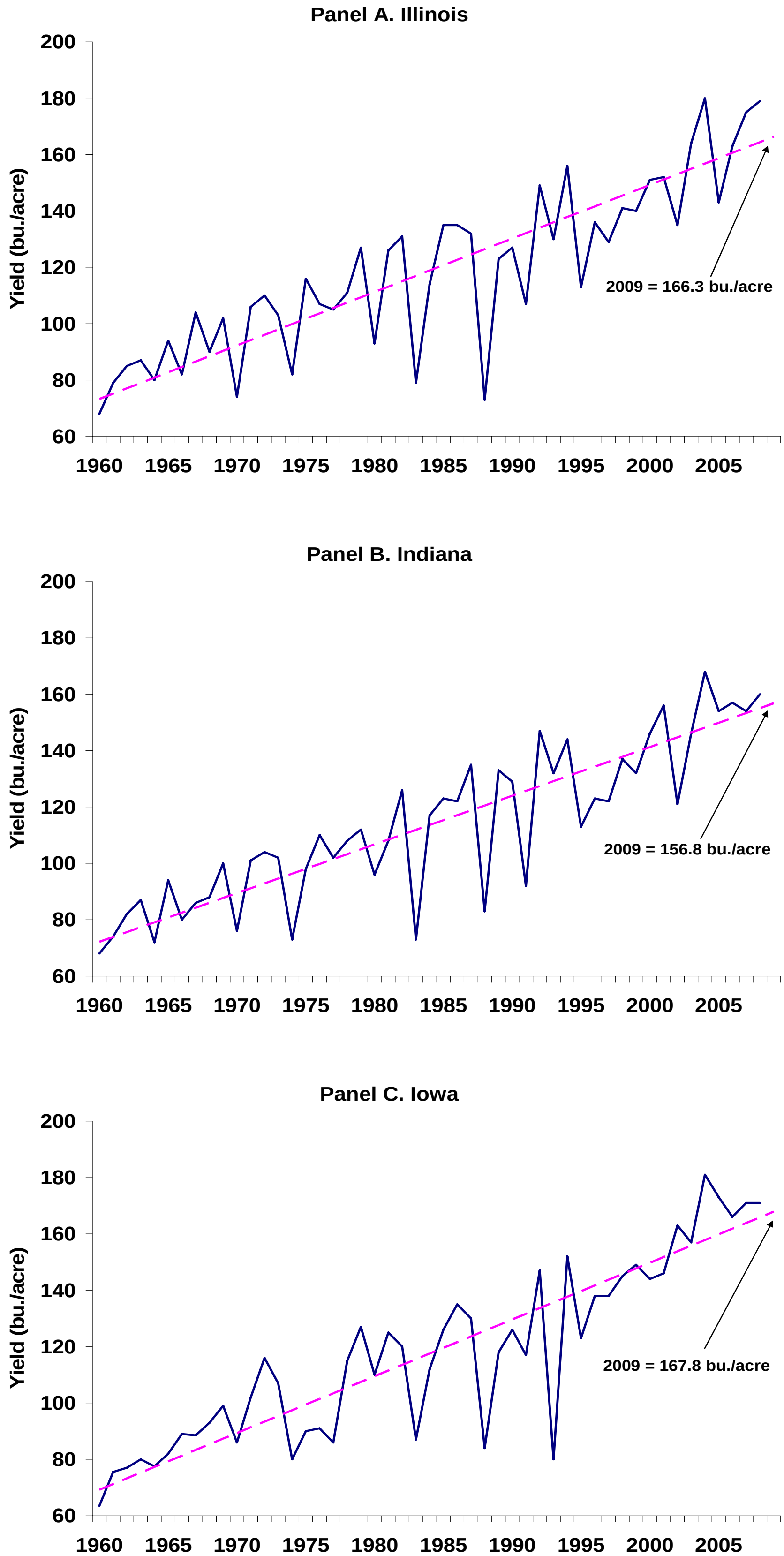

Figure 5. Actual and Trend Corn Yield in Illinois, Indiana, and Iowa, 1960-2008

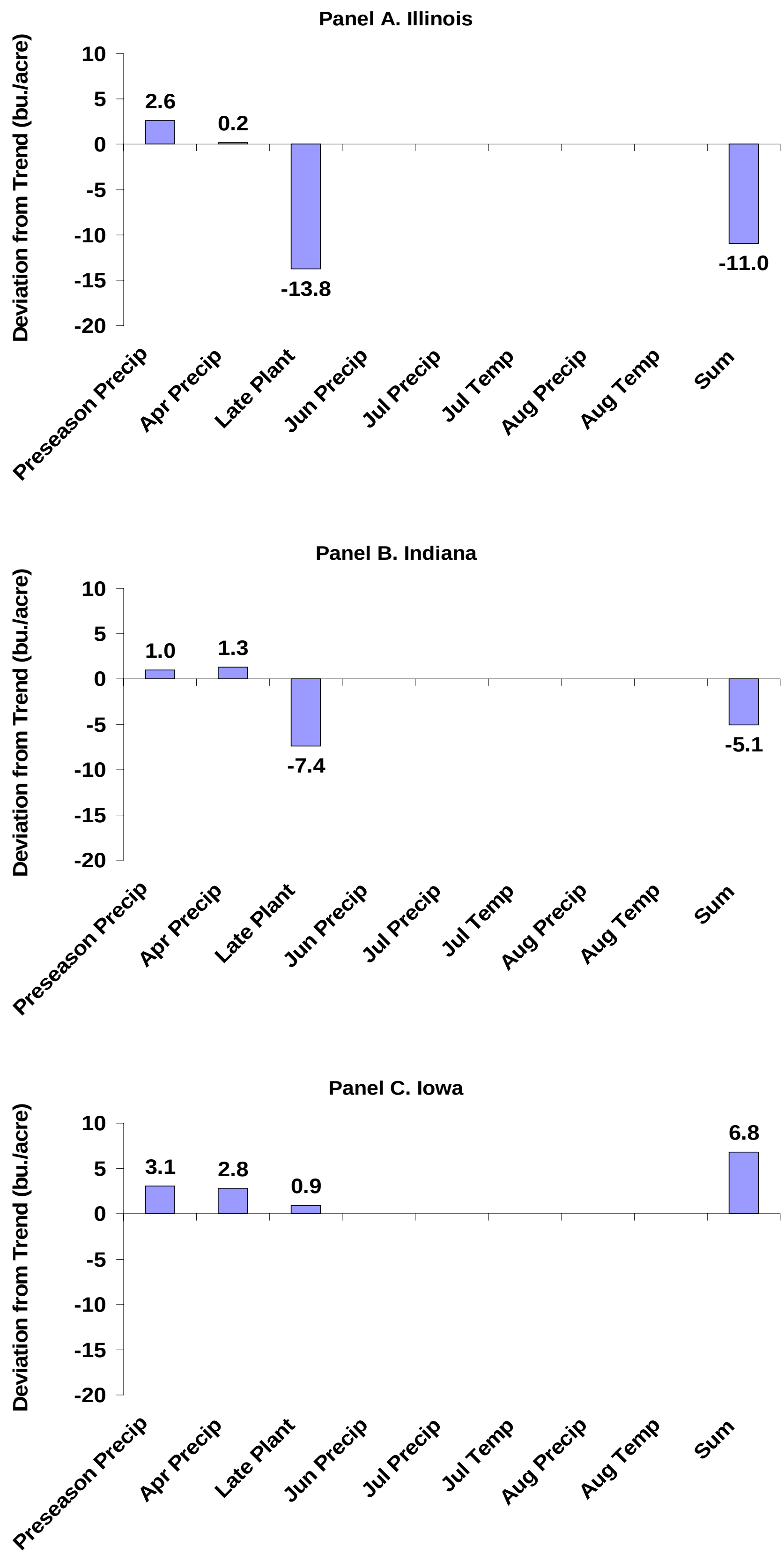

Figure 6. Estimated Impact of Monthly Weather and Late Planting Variables on Deviation from Trend Corn Yield in Illinois, Indiana, and Iowa in 2009