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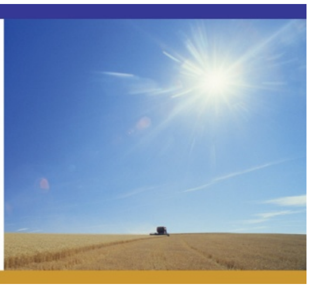

Alternative 2010 Corn Production Scenarios and Policy Implications

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INTRODUCTION[1]

The quantity of U.S. corn used for domestic ethanol production has grown rapidly in recent years, driven by mandated production levels of renewable biofuels, tax credits for ethanol blenders, and a tariff on imported ethanol. The United States Department of Agriculture (USDA) estimates that corn use for ethanol production increased from 1.603 billion bushels during the 2005-06 marketing year to 3.677 billion bushels during the 2008-09 marketing year. Use during the 2009-10 marketing year that started on September 1, 2009 is projected at 4.3 billion bushels. After appropriately adjusting the amount of corn used for ethanol by the production and feeding of the co-product distillers grains, net use of corn for ethanol production has increased from about 1.07 billion bushels in the 2005-06 marketing year to a projected 2.88 billion bushels in the current marketing year. Ethanol use accounted for 9.5 percent of total use in 2005-06 and a projected 22 percent in 2009-10.

One of the concerns that has emerged as corn use for ethanol has accelerated is that fuel use of corn could jeopardize the availability of corn for feed and food use, resulting in escalating food prices. This concern has been at least partially addressed by the observation that corn yields have trended higher over a long period of time and that the likely continuation of higher yields will result in ample supplies as corn use expands. Figure 1 presents the U.S. average annual corn yield from 1960 through 2009. There is a clear and persistent increase in average yields over time.

Higher corn yields over time are generally associated with improved corn production practices and the development and adoption of yield-enhancing technology (Egli, 2008). Some believe that the trend yield has been increasing at a faster rate since the mid-1990s and will increase at an even faster rate in the future due to biotechnology-driven improvements in seed genetics (e.g., Fitzgerald, 2006; Edgerton, 2009). In a similar vein, the consistency of annual average yields near trend value since 1996 is cited as evidence of reduced risk of a one-time weather-related shortfall in corn production. There appears to be growing confidence within the corn production industry that corn yields are “bullet proof.” As the yield shortfalls of the 1970s, 1980s, and early 1990s appear further in the rear view mirror, less concern is expressed about such risks in the future.

The general lack of concern about a weather-induced shortfall in U.S. corn production suggests that market participants

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[1] The authors thank Joe Glauber, Chris Hurt, Mindy Mallory, and Nick Paulson for numerous helpful comments on an earlier draft of this brief.

and policymakers may be ill-prepared to cope with such a shortfall should it occur, somewhat like the price spike of two years ago that caught participants off-guard. However, mainly due to good growing conditions in July and August in 2008, a large shortfall in production was averted and the extreme price spike was short-lived. A subsequent rationing of consumption was not required due to extremely weak export demand. A shortfall in production any time soon would likely result in the need for a cut in consumption and sustained high prices.

The purpose of this brief is three-fold. First, likely supply and consumption balance sheets for the 2010-11 marketing year are developed for three alternative corn yield scenarios, assuming no change in policies affecting corn consumption These yield scenarios include a U.S. trend yield, an average yield resulting from good weather, and an average yield resulting from poor weather. Second, the likely impacts of a low yield resulting from poor weather on various sectors of the corn market are presented in more detail. Third, potential policy responses to a low yield/high price scenario are discussed.

CORN YIELD MODELS

Generally overlooked in the "higher trend, reduced risk" yield argument is the role that weather patterns play in determining corn yields over time. We have previously estimated state level corn yield models for Illinois, Indiana, and Iowa for use in explaining and forecasting U.S. average corn yields (e.g., Irwin, Good, and Tannura, 2009a). These crop weather models were updated through 2009 and explain state average corn yield over 1960-2009 as a function of trend, percent of the crop planted late, and a number of weather variables. Those variables and the estimated linear regression coefficients are shown in Table 1. The model estimates show a large and statistically significant yield impact of April, June, July, and August precipitation and significant yield impacts of average July and August temperatures.[2]

Following Tannura, Irwin, and Good (2008), the possibility of a change in the trend rate of growth in corn yields is investigated using the crop weather models. Unknown breakpoint tests do not provide evidence of a statistically significant change in trend for any of the three states during the 1960-2009 sample period. Additional Chow tests that restrict the trend breakpoint to years since the mid-1990s (1995-2003) indicate only a few scattered cases of statistically significant increases in trend yields. Regardless of statistical significance, all of the estimated increases in trend after the breakpoints were quite small, typically on the order of only 0.1 to 0.2 bushels per year.

The previous results suggest that the relatively "high" corn yields since the mid-1990s were the result of a period of favorable weather for corn production, not an increase in the underlying corn trend yield. The generally favorable growing conditions for corn in recent years are illustrated in Figure 2, which shows total July and August precipitation and average July and August temperature from 1960 through 2009. Observations for these crucial months of the growing season are averaged across Illinois, Indiana, and Iowa in order to represent conditions across a wide swath of the Corn Belt. The incidence of low average summertime precipitation or above average summer temperatures has been less frequent since 1995 than in the previous period, particularly from the mid-1970s through the mid-1990s. If this pattern is not well-understood or ignored, the "high" yields in recent years can be easily attributed to technology instead of weather.

Another hypothesis is that corn yields are less sensitive to hot and dry weather

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[2] See Irwin, Good, and Tannura (2009a) for a detailed discussion of model development and estimation results.

conditions than in the past. This possibility is also investigated using the crop weather models. Unknown breakpoint tests were applied to the weather variables for each of the summer growing season months (e.g., a joint test of August precipitation and temperature variables). These tests uniformly provide no evidence of a statistically significant change in precipitation and temperature coefficients for any of the three states over the 1960-2009 sample period. Additional Chow tests that restrict the trend breakpoint to years since the mid-1990s (1995-2003) provide similar results for Illinois and Indiana, but reveal evidence of a small and statistically significant decline in the sensitivity of Iowa corn yields to July and August temperatures starting in 2002. The decline is about one-tenth of a bushel less responsiveness per degree of temperature. At best, these statistical tests provide only marginal evidence that corn yields are becoming less sensitive to hot and dry weather conditions than in the past. It should be noted that the lack of a widespread and severe drought since the mid-1990s may mean there simply is not enough variation in the data to consistently detect improved drought tolerance with the time-series regression models used here.

We also previously estimated a model of U.S. average corn yields using USDA crop condition ratings (e.g., Irwin, Good, and Tannura, 2009b). Each week during the growing season the USDA reports the percentage of the crop rated in very poor, poor, fair, good, and excellent condition. The crop condition model, estimated over the period 1986 through 2009, explains the U.S. average corn yield as a function of time (trend), percent of the U.S. crop planted late, and the percent of the crop rated as either good or excellent in the last rating of the season.[3] The model estimates are presented in the last column of Table 1 and show a highly significant relationship between crop conditions ratings and corn yield. Specifically, U.S. average corn yield is estimated to increase 0.64 bushels for each one percentage point increase in the sum of good and excellent ratings.[4]

A large body of literature indicates that when multiple forecasts of the same variable are available, a simple-average of the forecasts generally is more accurate than any of the individual forecasts (e.g., Timmerman, 2006). Based on this finding, an equally-weighted average of the crop weather and crop conditions forecasts is used as the point forecast in projecting 2010 U.S. corn yields. This approach worked well in accurately forecasting the U.S. average corn yield in 2008 and 2009, years of generally favorable summer weather (e.g., Irwin, Good, and Tannura, 2008, 2009b). However, the out-of-sample forecasting accuracy of the models has not yet been validated under adverse summer weather conditions.

While our statistical test results indicated only marginal evidence of a lessened sensitivity of corn yields to hot and dry weather conditions, Yu and Babcock (2009) use less aggregated data and conclude that corn yields are substantially less sensitive to drought conditions than in the past. However, Yu and Babcock's evidence is based on a limited sample of drought events and geographic areas and a single index of drought conditions. Huffman (2009) argues that improved corn root structures associated with transgenic traits for rootworm resistance is a major advantage in dry weather conditions. Changnon and Winstanley (2000) make the interesting observation that poor weather conditions may have a larger negative impact on corn

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[3] Crop conditions ratings for corn are not available on a national basis before 1986.

[4] The possibility of a change in the trend rate of growth in corn yield and lessened sensitivity to ratings is also analyzed for the crop conditions model. Unknown breakpoint tests and Chow tests using 2000 as a breakpoint fail to find statistically significant changes.

yields now than in the past due to much higher plant populations that greatly increase demand for soil moisture. Given the unsettled nature of this debate, we believe it is prudent to continue to rely on a relatively long history of corn yield and weather interactions as a guide to the future. Therefore, we assume that the combination of our crop weather and crop conditions models provides unbiased estimates of corn yield shortfalls due to poor weather conditions.

2010 YIELD SCENARIOS

Using the crop weather models, a trend yield is calculated for Illinois, Indiana, and Iowa for 2010. Each state calculation is then weighted by the corn acreage harvested in that state in 2009 to generate a three state-weighted trend yield. The three state-weighted trend yield is divided by the average ratio of three state-weighted yield to the U.S. average yield for the period 2005 to 2009 (1.09) to produce a U.S. trend yield forecast. This is similar to the procedure that was used to forecast the U.S. average trend yield in 2009 (Irwin, Good, and Tannura, 2009a). This procedure results in a trend yield forecast for 2010 of 152.7 bushels.

The following procedure is used to forecast 2010 yield under a poor weather scenario using the crop weather models. For each state, the five poorest growing seasons since 1960 are identified. Five years are selected in order to estimate the potential yield impact of an event with a 1 in 10 chance of occurring. The five poorest years are identified by applying the model to each year from 1960 through 2009, assuming 2010 production technology, and identifying the five years with the lowest yield forecasts. The average yield forecasts for these years are averaged to generate a poor weather yield forecast for 2010. The three state yield forecasts are used to calculate a U.S. yield forecast using the procedure described above. The calculated forecast is 126.5 bushels per acre.

A forecast of 2010 corn yield under a good weather scenario is similar to that used for a poor weather scenario, except the five highest yield forecasts for each state are averaged. That procedure results in a U.S. yield forecast of 169.9 bushels per acre.

The crop condition model is also used to calculate trend yield, assuming 2010 technology. That calculation is 160.7 bushels per acre. The model is then applied to the three years from 1986 through 2009 with the lowest crop condition ratings at the end of the growing season, assuming 2010 technology. Again, three years are selected in order to estimate the potential yield impact of an event with a 1 in 10 chance of occurring. The average of those three is used to forecast the 2010 yield under poor weather conditions. Similarly, the model is applied to the three years with the highest crop condition ratings and the average of the three is used to forecast 2010 yields under good growing conditions. Those forecasts are 142.4 bushels and 175.1 bushels, respectively.

Finally the trend forecast, poor weather forecast, and good weather forecast from each model is averaged to produce the respective composite forecasts for 2010. Those are as follows:

Trend – 156.7 bushels per acre
Poor Weather – 134.5 bushels per acre
Good Weather – 172.5 bushels per acre.

As noted above, the poor and good weather forecasts are meant to represent approximately 1 in 10 weather events. While these are relatively infrequent events it is important to keep in mind that they do not represent the most extreme outcomes predicted by the models. For example, choosing the worst single year for each model and averaging (about a 1 in 30 event) would result in a poor weather yield forecast of 123.6 bushels per acre.

PRODUCTION, CONSUMPTION, AND PRICE SCENARIOS FOR 2010

The alternative yield forecasts are used to generate alternative production forecasts for 2010. Since acreage is not yet known, the yield forecasts are applied to the planted acreage forecast presented by USDA at the Agricultural Outlook Forum on February 18 and 19, 2010. Planted acreage of corn was projected at 89 million, with acreage harvested for grain projected at 81.8 million. The difference between planted and harvested acreage would be expected to vary among average, good, and poor weather scenarios. A larger portion of the acreage tends to be harvested for grain under favorable growing conditions, less under poor growing conditions. We use a forecast of 82.1 million and 81.5 million acres harvested for good and poor weather scenarios, respectively. The USDA will release a *Prospective Plantings* report on March 31, 2010 and an *Acreage* report on June 30, 2010. These reports will contain survey based acreage estimates for 2010.

Table 2 shows the USDA's projected corn balance sheet for the 2009-10 marketing year as of March 10, 2010 and our projected balance sheets for 2010-11under the three production scenarios described above. The trend and good weather scenarios result in ample supplies of corn, allowing consumption to expand and maintain adequate year-ending inventories. The good weather scenario would likely result in an average farm price well below recent averages. The poor weather scenario would require a substantial reduction in corn consumption during the 2010-11 marketing year. Year ending stocks would likely be reduced to near pipeline levels and the average farm price of corn would likely be very high compared to recent averages. It is this scenario that would be troublesome for users of corn and likely result in a higher rate of increase in food costs.

CONSUMPTION AND PRICE IMPLICATIONS OF A YIELD SHORTFALL IN 2010

Calculations presented above project 2010 corn production at 10.962 billion bushels under poor growing conditions. That is 2.169 billion bushels less than the record crop of 2009. Under this scenario, consumption of U.S. corn for all purposes would be limited to about 12.075 billion bushels, 940 million bushels (7.2 percent) less than expected to be consumed during the current marketing year. This reduction would be slightly less than the 8.6 percent reduction required by the most recent production shortfall in 1995.

Historically, the largest reduction in corn use during years of shortage occurs in the domestic feed sector. The demand for corn in that sector is more price elastic than in the export sector or the domestic processing sectors. That is, consumption is more responsive to price in the feed sector than in other sectors. The key question then is how big of a reduction in feed use would be required in 2010-11 with a crop of 10.962 billion bushels. The answer to this question hinges to a considerable degree on the amount of corn that would be used for ethanol production.

Use of corn in the ethanol sector is compelled by legislative mandates for renewable biofuel consumption under the 2007 Renewable Fuels Standards Program (RFS2). That mandate is at 12 billion gallons for the 2010 calendar year and 12.6 billion gallons for the 2011 calendar year. We calculate the mandate at 12.4 billion gallons for the 2010-11 corn marketing year. Under the assumption that the mandate would continue to be met from corn based ethanol production, about 4.4 billion bushels of corn would be required. Part of the biofuels consumption mandate in a given year can be met by credits from consumption in the previous year that exceeded the mandated level. Each gallon of ethanol is assigned a Renewable Identification Number (RIN). RINs for surplus ethanol blending can be retained for up to 14 months and used to meet future blending mandates. Under a scenario of high corn prices and modest gasoline prices, production of ethanol could become uneconomic. Rather than bid the price of ethanol above the price that provides acceptable blending margins in order to motivate production, blenders could use available RINs to meet a portion of the mandate. The likely availability of RINs during the 2010-11 marketing year is not known. Based on current availability, we estimate that if blending became uneconomic corn use for ethanol production could be 100 million less than required by the mandate. Blenders of ethanol can also "borrow" against future mandates, but those borrowings must be made up the following year. Uncertainty about future blending economics would likely make borrowing unattractive.

Corn used for other processing purposes, mostly starch and high fructose corn syrup, might decline modestly under a small supply scenario. In general, higher corn prices would be passed on to the consumers of these products. Similarly, corn exports would not be expected to be substantially smaller than under the other two scenarios. Importers would likely buy according to need, regardless of short term price movements. This is particularly the case for Japan, the largest buyer of U.S. corn. There is some possibility that other grains would substitute for U.S. corn in the world feed market. Large South American supplies of corn or a continuation of large supplies of feed wheat might result in a sharper decline in U.S. corn exports.

If domestic use of corn for other processing uses dropped to 1.225 billion bushels and exports were at 1.925 billion bushels, 4.625 billion bushels would be available for feed use of corn. That level of use would represent a 16.7 percent year-over-year decline in feed use. That is larger than the 14 percent decline experienced in 1995-96. Some of the adjustment in corn feeding might be accommodated by increased feeding of other grains if supplies were adequate. Domestic supplies of wheat, for example, are currently large. Under the poor weather scenario presented here, however, there would not be a year-over-year increase in the supply of distillers' grain.

The price of corn under the scenario of poor weather would be influenced by two factors: 1) the price required to reduce corn feeding by 16.7 percent and 2) the price ethanol producers could afford to pay for corn. It is a bit easier to conceptualize the latter price. The price ethanol producers could afford to pay for corn would depend on the price of ethanol and the minimum operating margins acceptable to ethanol producers. Since ethanol is sold on a volumetric basis at the retail level (same price as gasoline) the maximum value of ethanol can be thought of as the price of gasoline plus the $.45 per gallon tax credit that ethanol blenders receive. For example, if gasoline is priced near the current level of deferred futures of $2.10 per gallon and blenders are willing (forced) to pass the entire tax credit back to ethanol producers, the maximum price of ethanol in the wholesale market would be $2.55. Allowing for transportation costs, the maximum price to the ethanol producer would be about $2.40. Based on current models of the cost structure of ethanol plants and the current price of natural gas, ethanol priced at $2.40 per gallon results in a maximum price of corn of $7.23 per bushel in order for ethanol producers to cover variable costs of production and a maximum price of $6.44 per bushel in order to cover variable and fixed costs, but no return to equity. Corn prices then, could go to very high levels before ethanol blending and production would become completely uneconomic.

Recent history provides some insight about behavior of livestock producers in an environment of high corn prices. That history suggests that livestock producers are reluctant to reduce animal numbers in the face of high priced corn. Hog producers, for example, expanded production rapidly in 2007 as corn prices started to move higher. The number of sows farrowed declined modestly in 2008 and 2009, but remained above the pre-2007 level. The U.S. cattle inventory declined only about 1.5 percent in 2008, while poultry production actually increased in 2008.

A reduction in livestock production was required in 1995-96 due to a shortage of corn. Most of the reduction occurred in pork production, which was down 4 percent in 1996. Poultry production actually expanded in 1996. Feed use of corn declined 14 percent during the 1995-96 marketing year, but the decline came slowly. Year-over year consumption was down about 10 percent during the first three quarters of the year and down nearly 38 percent in the final quarter. The U.S. average price of corn received by farmers for the 1995 crop was a record $3.24, 43 percent higher than the average during the previous marketing year. The average daily cash price of corn in central Illinois reached a high of $5.25, 32 percent higher than the previous record high established in 1974.

Livestock producers would likely respond to short supplies and high prices of corn more quickly in the next year or two than in the recent past. Low livestock prices and high feed costs over the past two years have resulted in operating losses and an erosion of equity for many producers. A period of high corn prices now would likely result in significant financial stress on many producers of livestock and livestock products resulting in substantial liquidation of livestock numbers and a decline in production of meat and milk. The decline in livestock product output, such as milk, would be immediate while declines in meat production would be delayed as inventory is consumed.

The implication of the likely scenario described above is that corn prices might not have to increase as much now to force liquidation of livestock numbers as in previous periods when the industry was financially stronger. However, the reduction in livestock numbers would likely be quicker and deeper than in similar situations in the past. The "breakeven" corn prices for ethanol production estimated above would likely be well above the price livestock producers would be willing to pay for corn

Under the poor weather scenario for 2010 outlined above, we expect that the 2010-11 marketing year average farm price would be near $5.75 per bushel. Daily highs in the cash price of corn in the Corn Belt might be near the $7.00 level experienced in the 2007-08 marketing year.

POLICY IMPLICATIONS OF POOR WEATHER

In the past, some policy changes have been implemented in cases of a shortfall in crop production, but for the most part it has been left to the market to sort out the allocation of a short crop. In some instances, rules preventing haying and grazing on conservation lands were altered to allow livestock producers access to additional feed supplies. Another option that has been proposed and implemented occasionally is a temporary restriction on exports. Such a restriction was implemented for soybeans in the spring of 1973. Corn exports to Russia were restricted in January 1980, but for political and not economic reasons. In 2008, there were some calls for providing relief from high corn prices for livestock producers by limiting the use of corn for ethanol production. There was also some effort to allow early release of some Conservation Reserve Program (CRP) land for crop production in 2009. Since the 2008 crop was large and prices moderated fairly quickly, no changes in ethanol policy were implemented and no change in CRP enrollment was made.

The question still remains: Should additional policy options be considered in the case of a shortfall in corn production, or should the role of allocation be left solely to the market? Under the latter scenario, with biofuels mandates left in place, the burden for adjustment would fall primarily on the domestic livestock sector, resulting in financial losses for livestock producers, and eventually in reduced meat supplies and higher retail prices. Higher corn prices would also be passed along to the consumers of corn-based food products.

In fact, there are probably a limited number of additional policy alternatives for addressing a shortfall in corn production. We (and others) have suggested that a modest physical reserve be considered to help reduce the negative impacts of a shortfall (Good and Irwin, 2007). However, previous experience with reserve schemes suggests this is an expensive alternative of uncertain effectiveness (Wright, 2009).

Another alternative is to design more flexibility into current renewable biofuels policies.[5] Specifically, since corn use for ethanol production accounts for such a large part of total consumption of U.S. corn and since such use is primarily driven by mandates, a tax incentive, and an import tariff, some short-term flexibility in those policies might be considered in the case of a large weather-related production shortfall. In particular, a relaxation of the annual renewable biofuels mandate could be implemented in an "emergency" situation. In addition, a reduction in the tax incentive for blenders could be considered if blending economics pointed to use in excess of a revised mandate. A third option would be to lower the tariff on imported biofuels to allow a larger portion of the mandate to be met with imported biofuels. In extreme circumstances, such as sharply higher gasoline prices, the removal of the biofuels mandate, tax incentive, and import tariff might be insufficient to limit ethanol production since the economics of blending would remain favorable. In such cases a cap on ethanol production, exports, or both might have to be considered.

The primary financial burden of a reduction in biofuels production would fall on the producers of ethanol. Compensation for losses could be considered, but historically corn users bearing the burden of production shortfalls have not been compensated. The budget allocation for the biofuels blender tax credit, however, would be a potential source of compensation funds. The extent of any changes in biofuels policies would logically be a function of the magnitude of the shortfall in production and the proportion of the shortfall that is allocated to ethanol production. Targets for corn use in ethanol production would be determined by an assessment of the appropriate size of the feed supply of corn.

In closing, we want to emphasize that our purpose is not to proscribe the appropriate policy response to a shortfall in corn production or to define how policy changes should be implemented, but to encourage policymakers to establish a set of responses in advance of such an occurrence. An established set of responses would be extremely valuable to those in the industries impacted and allow a quick and efficient policy response. Renewable fuels policy would likely be an important component of that policy response. A waiver procedure already exists for altering the RFS2 mandates but it is a lengthy process not well-suited to the types of production shortfalls that would fall into the "emergency" category. In addition, lower mandates may be not be sufficient to limit corn use for ethanol if blending economics are favorable. We believe it is imperative that a process be initiated now to determine how to deal with such situations rather than putting our figurative heads in the sand and hoping it does not occur. History suggests it is not a question of whether or not a shortfall in corn production will occur, but instead the questions are: When? and How severe?

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[5] Our use of the term "renewable" biofuels mandate is equivalent to "conventional" or "non-advanced" biofuels mandate.

REFERENCES

Changnon, S.A., and D. Winstanley. “Long-Term Variations in Seasonal Weather Conditions Important to Corn Production in Illinois.” *Climatic Change* 47(2000):353-372.

Edgerton, M.D. “Increasing Crop Productivity to Meet Global Needs for Feed, Food, and Fuel.” *Plant Physiology* 149(2009):7–13.

Egli, D.B. “Comparison of Corn and Soybean Yields in the United States: Historical Trends and Future Prospects.” *Agronomy Journal* 100(2008):S79-S88

Fitzgerald, A. “300 Bushels per Acre Corn Yield No Longer a Pie-In-Sky Goal.” *Des Moines Register*, December 11, 2006.

Good, D. and S. Irwin. “2007 U.S Corn Production Risks: What Does History Teach Us?” Marketing and Outlook Brief 2007-01, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, May 2007. Available online: http://www.farmdoc.illinois.edu/marketing/mobr/mobr_07-01/mobr_07-01.pdf

Huffman, W. “Technology and Innovation in World Agriculture: Prospects for 2010-2019.” Working Paper #09007, Department of Economics, Iowa State University, 2009. Available online: http://econ2.econ.iastate.edu/research/webpapers/paper_13060_09007.pdf.

Irwin, S., D. Good, and M. Tannura. “Forming Expectations About 2008 U.S. Corn and Soybean Yields—Application of Crop Weather Models that Incorporate Planting Progress.” Marketing and Outlook Brief 2008-03, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, July 2008. Available online: http://www.farmdoc.uiuc.edu/marketing/mobr/mobr_08-03/mobr_08-03.pdf.

Irwin, S., D. Good, and M. Tannura. “Early Prospects for 2009 Corn Yields in Illinois, Indiana, and Iowa.” Marketing and Outlook Brief 2009-01, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, June 2009a. Available online: http://www.farmdoc.illinois.edu/marketing/mobr/mobr_09-01/mobr_09-01.pdf.

Irwin, S., D. Good, and M. Tannura. “2009 Final Corn and Soybean Yield Forecasts.” Marketing and Outlook Brief 2009-06, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, September 2009b. Available online: http://www.farmdoc.illinois.edu/marketing/mobr/mobr_09-06/mobr_09-06.pdf.

Tannura, M.A., S.H. Irwin, and D.L. Good. “Are Corn Trend Yields Increasing at a Faster Rate?” Marketing and Outlook Brief 2008-02, Department of Agricultural and Consumer Economics, February 2008. Available online: http://www.farmdoc.illinois.edu/marketing/mobr/mobr_08-02/mobr_08-02.pdf.

Timmermann, A. “Forecast Combinations.” in G. Elliot, C.W.J. Granger, and A. Timmermann, eds., *Handbook of Economic Forecasting, Volume 1.* North Holland: Amsterdam, NL, 2006, pp. 135-196.

USDA/WASDE. *World Agricultural Supply and Demand Estimates.* World Agricultural Outlook Board, U.S. Department of Agriculture, WASDE-480, March 10, 2010. Available online: http://www.usda.gov/oce/commodity/wasde/latest.pdf.

Wright, B. “International Grain Reserves and Other Instruments to Address Volatility in Grain Markets.” Policy Research Working Paper 5028, The World Bank, 2009. Available online: http://econ.worldbank.org/external/default/main?pagePK=64165259&theSitePK=469372&piPK=64165421&menuPK=64166093&entityID=000158349_20090825154655

Yu, T., and B.A. Babcock. “Are U.S. Corn and Soybeans Becoming More Drought Tolerant?” Working Paper 09-WP 500, Center for Agricultural and Rural Development, Iowa State University, 2009. Available online: http://www.card.iastate.edu/publications/DBS/PDFFiles/09wp500.pdf.

Table 1. Regression Estimates of Crop Weather Models for Illinois, Indiana, and Iowa Corn Yield and Crop Conditions Model for U.S. Corn Yield

	Coefficient Estimates			
Independent Variable or Statistic	**Illinois**	**Indiana**	**Iowa**	**U.S.**
Constant	244.63 ***	222.24 ***	190.95 ***	64.11 ***
	(3.75)	(3.68)	(3.18)	(17.05)
Annual Time Trend	1.88 ***	1.72 ***	1.96 ***	2.37 ***
	(24.51)	(20.13)	(21.90)	(24.68)
Late Planting	-0.31 ***	-0.18 ***	-0.36 ***	-0.15 **
	-(3.94)	-(2.95)	-(2.87)	-(2.49)
Preseason Precipitation	1.52	3.21	7.00 **	
	(0.52)	(1.17)	(2.17)	
Preseason Precipitation^2	-0.02	-0.07	-0.24 *	
	-(0.30)	-(1.06)	-(1.95)	
April Precipitation	14.30 **	9.44 **	10.64 **	
	(2.68)	(2.05)	(2.03)	
April Precipitation^2	-1.57 **	-1.03 *	-1.29 *	
	-(2.41)	-(1.79)	-(1.78)	
June Precipitation	12.68 ***	14.40 ***	7.77 *	
	(3.16)	(3.87)	(2.00)	
June Precipitation^2	-1.35 ***	-1.49 ***	-0.67 *	
	-(3.12)	-(3.51)	-(1.85)	
July Precipitation	19.67 ***	15.50 ***	16.91 ***	
	(3.36)	(4.60)	(6.07)	
July Precipitation^2	-1.74 **	-1.24 ***	-1.59 ***	
	-(2.63)	-(3.78)	-(5.83)	
August Precipitation	0.72	10.75 *	-0.61	
	(0.14)	(1.88)	-(0.22)	
August Precipitation^2	0.01	-1.24 *	0.11	
	(0.02)	-(1.76)	(0.43)	
July Temperature	-1.61 **	-1.96 ***	-1.60 **	
	-(2.37)	-(3.11)	-(2.62)	
August Temperature	-2.37 ***	-2.11 ***	-1.78 ***	
	-(4.60)	-(3.94)	-(3.26)	
Crop Conditions Rating				0.64 ***
				(13.54)
R^2	0.96	0.95	0.96	0.98
Standard Error (bu./acre)	7.25	7.31	8.15	3.23
Regression F-statistic	58.89 ***	50.57 ***	53.17 ***	262.40 ***

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 1986-2009 at both the state and national level. Crop conditions rating is the sum of final good and excellent percentage rating categories for each year. Crop weather models are estimated over 1960-2009 and the crop conditions model is estimated over1986-2009.

Table 2. U.S. Corn Balance Sheets for 2009/10 and 2010/11

		2010/11 Yield Scenario		
	2009/10	**Trend**	**Good Weather**	**Poor Weather**
Supply				
Planted acreage (mil.)	86.0	89.0	89.0	89.0
Harvested acreage (mil.)	79.6	81.8	82.1	81.5
Yield (bu/ac.)	164.9	156.7	172.5	134.5
Production (mil. bu.)	13,131	12,818	14,162	10,962
Beginning stocks (mil. bu.)	1,673	1,799	1,799	1,799
Imports (mil. bu.)	10	10	10	15
Total (mil. bu.)	14,814	14,627	15,971	12,776
Consumption				
Exports (mil. bu.)	1,900	2,000	2,100	1,925
Feed and residual (mil. bu.)	5,550	5,375	5,550	4,625
Ethanol (mil.bu.)	4,300	4,500	4,700	4,300
Other processing (mil. bu.)	1,265	1,270	1,300	1,225
Total (mil. bu.)	13,015	13,145	13,650	12,075
Ending stocks (mil. bu.)	1,799	1,482	2,321	701
Stocks-to-use	13.8	11.3	17.0	5.8
Average farm price ($/bu.)	$3.60	$3.80	$3.20	$5.75

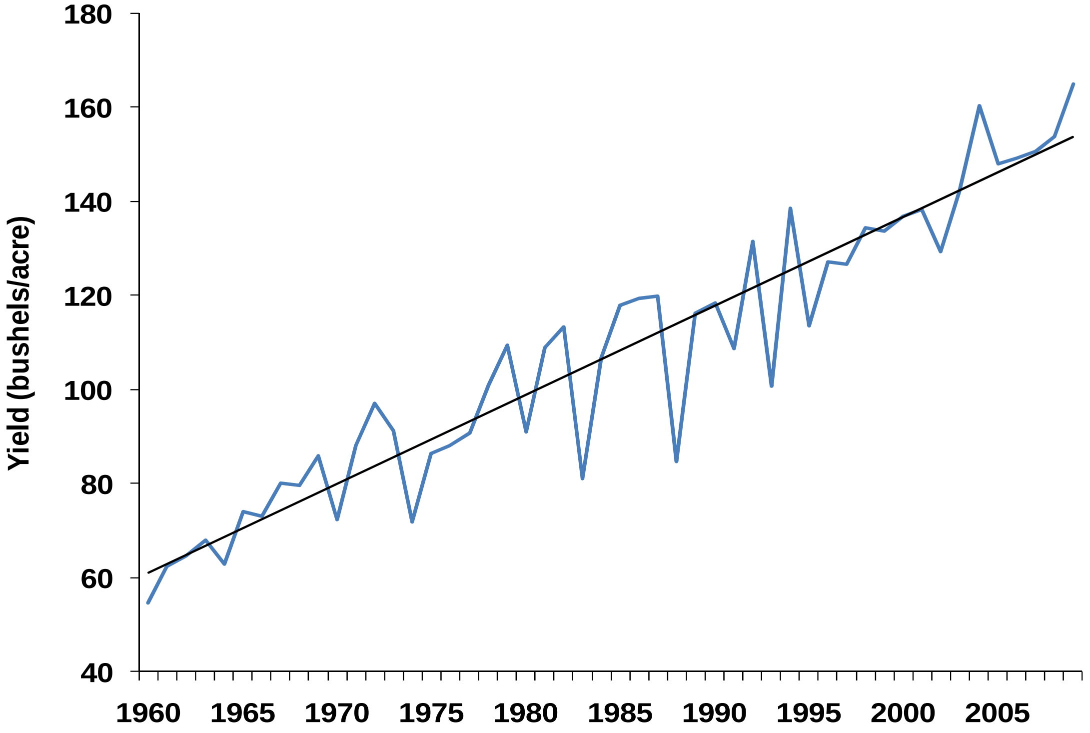
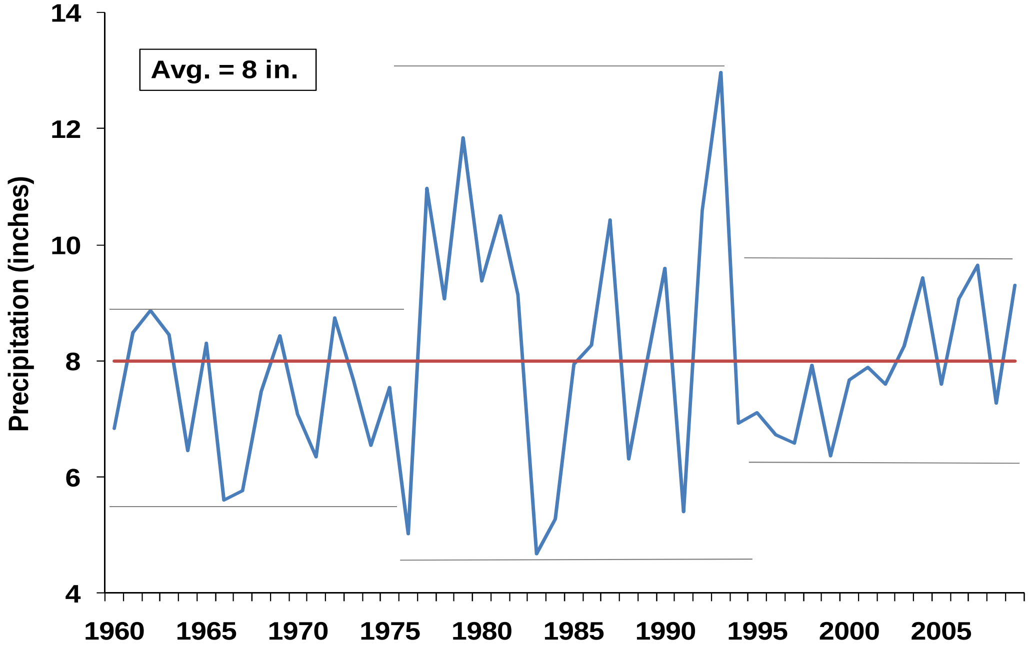


Figure 1. U.S. Average Corn Yield, 1960-2009

Panel A: Total July-August Precipitation



Panel B: Average July-August Temperature

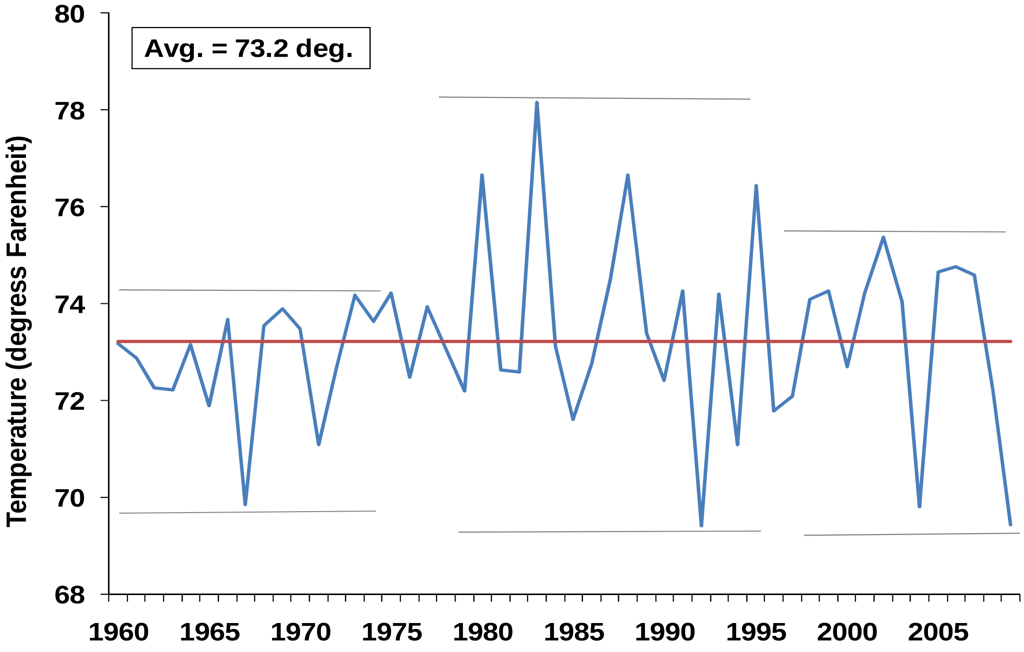


Figure 2. Total July-August Precipitation and Average July-August Temperature, Illinois, Indiana, and Iowa Averages, 1960-2009