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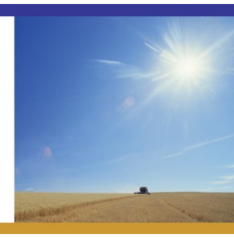

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Evaluation of Selected USDA WAOB and NASS Forecasts and Estimates in Corn and Soybeans

Executive Summary

The United States Department of Agriculture (USDA) has a number of agencies that are involved in collecting, analyzing, forecasting, and disseminating information about the production and consumption of the corn and soybean crops (Spilka, 1983; Vogel and Bange, 1999; Lusk, 2013). Market participants rely heavily on estimates and forecasts provided by these agencies in order to form price expectations and to make business decisions. In spite of on-going efforts to maintain the quality of information provided and the transparency of the methodology used, misunderstanding, concerns, or complaints about the information provided periodically arise (e.g., USDA/ESRP, 1985; Good and Irwin, 2011). More recently (since 2006) those concerns have centered on the accuracy of the quarterly estimates of corn inventories and to a lesser extent on the methodology and accuracy of early season yield forecasts (e.g., Polansek, 2010; Pleven and McGinty, 2011). It is in that context that this review of USDA forecasts and estimates for corn and soybeans was conducted.

The main findings of the statistical analysis are as follows:

- WAOB corn and soybean yield forecasts made in May, June, and July do not have a substantial bias. The accuracy of the forecasts also has not changed markedly over the 1993-2012 time period for either corn or soybeans. With a few exceptions, WAOB corn and soybean forecast errors since 2006 generally are within the historical range of errors.

- NASS yield forecasts for corn reveal no evidence of bias in any month over 1990-2012 and forecast errors since 2006 are well within the historical range of errors. There is some evidence of improvement in the accuracy of NASS corn yield forecasts over time. Soybean forecast errors since 2006 are also within the historical range, except for September and October 2012, and there is no statistical change in the magnitude of forecast errors for soybean yields over time. However, there is a general tendency for soybean forecasts to be conservative, in the sense of underestimating final yield. In addition, market analysts consistently under-estimated NASS production forecasts during the first half of the sample and over-estimated production forecasts during the second half.

- There has been a sharp decline in market analysts' ability to anticipate quarterly corn usage as implied by NASS *Grain Stocks* reports since the start of the 2006 marketing year. Double-digit implied usage surprises occurred

three times during 2006-2012 and each one substantially exceeded the largest surprise observed over 1990-2005. The most problematic corn stocks estimates occurred in the 2009, 2010, and 2012 marketing years. Within these three problematic years there was also a clear tendency towards reversal of the surprises from quarter-to-quarter.

Given the evidence of a sharp decline in market analysts' ability to anticipate quarterly corn usage since the start of the 2006 marketing year, we considered a number of potential explanations for the decline offered by various market participants. Based on the statistical evidence regarding implied usage surprises we developed four criteria that an explanation needs to satisfy in order to be credible: i) Why corn and not soybeans?, ii) Why 2006-2012 and not earlier?, iii) Why only in particular marketing years?, and iv) Why a pattern of reversals during marketing years? Using these criteria, we showed that all but one of the potential explanations offered to date clearly fails to satisfy at least one of the criteria. The explanation with the most merit is that unresolved errors in production estimates for corn led to the large surprises. NASS stocks estimates undoubtedly encompass sampling errors for both production and stocks estimates and it is likely that unresolved sampling errors for corn production estimates are large enough to explain the surprises. It is more difficult to pin down exactly why unresolved sampling errors for corn production estimates were concentrated in 2009, 2010, and 2012 and caused the quarter-to-quarter reversal pattern in surprises, but reasonable arguments can be put forward. Nonetheless, it is important to emphasize there is no "smoking gun" in terms of the available evidence on the impact of unresolved production sampling errors, with some of the evidence best described as circumstantial.

Based on our analysis and evaluation, we offer the following recommendations regarding USDA corn and soybean forecasts and estimates:

- The WAOB should describe in a written document the exact process used to determine corn and soybean yield forecasts for each month, including the roles of crop weather regression forecasts, subjective judgment, and any other inputs, and this document should be available on the WAOB website and explicitly referenced and hyperlinked in the footnotes of the relevant supply and demand tables in May, June, and July *World Agricultural Supply and Demand Estimates* (WASDE) reports.

- NASS should institute an internal review of soybean yield forecasting procedures to determine the source of any bias and make changes needed to insure it is eliminated.

- NASS should “open up the black box” for each monthly corn and soybean yield forecast as much as possible. This should include: i) presentation of state and national yield forecasts derived from the agricultural yield survey (AYS) and the objective yield survey (OYS), as well as the usual composite forecast derived from the two surveys, ii) presentation of assumptions regarding fruit weights used in deriving OYS yield forecasts during forecast months when these measurements are not available, and iii) some form of recognition of the degree to which weather and crop condition data influence composite forecasts.

- NASS should initiate a research project to study how yield monitor data could be incorporated into crop yield estimation procedures.

- NASS should initiate an internal review of corn stock estimation procedures in an effort to determine whether any methodological problems are apparent.

- NASS should provide the same instructions regarding weight per bushel that it provides to off-farm survey respondents to on-farm survey respondents

- NASS should investigate the possibility of adding grain stocks questions to the Agricultural Census.

- NASS should engage market participants in a discussion of the appropriate interpretation of grain stocks estimates and consider what means might be available to improve the general understanding of the limits of stock estimates for implying usage.

- WAOB and NASS should evaluate the potential costs and benefits of adding a survey of corn feed use that would allow a fuller accounting of corn usage similar to what has been historically possible for soybeans.

- WAOB and NASS should investigate the potential costs and benefits of adding a survey of ethanol plants to provide more accurate estimates of corn used in ethanol production.

- WAOB and NASS should seek funding to replace the former monthly Census Bureau M311J *Fats and Oils: Oilseed Crushings* report.

Evaluation of Selected USDA WAOB and NASS Forecasts and Estimates in Corn and Soybeans

Introduction

The prices of corn and soybeans are influenced by a wide range of ever-changing world and domestic factors that determine the supply of and demand for these crops. Since the U.S. is a major producer of these crops, the magnitude of U.S production, the pace of domestic consumption, and the level of domestic inventories are among the most important factors influencing prices. The United States Department of Agriculture (USDA) has a number of agencies that are involved in collecting, analyzing, forecasting, and disseminating information about the production and consumption of these crops (Spilka, 1983; Vogel and Bange, 1999; Lusk, 2013). Market participants rely heavily on estimates and forecasts provided by these agencies in order to form price expectations and to make business decisions. For corn and soybeans, three of the more important reports provided by the USDA are the World Agricultural Outlook Board (WAOB) *World Agricultural Supply and Demand Estimates* report and the National Agricultural Statistics Service (NASS) *Crop Production* and *Grain Stocks* reports. Due to their comprehensive nature, objectivity, and timeliness, USDA reports are widely-considered to be benchmarks for other public and private forecasts (Purcell and Koontz, 1999; Vogel and Bange, 1999; Lusk, 2013). The information contained in these reports also tends to provide for a "level playing field" for market participants. That is, the information is valuable to all participants, but would not likely be available to all participants absent the USDA effort to provide the information.

The USDA has long recognized the importance of providing timely and accurate information and the need to maintain good working relationships with those who provide basic data for these reports and with those who use the estimates and forecasts.[1] Procedures for most data collection, analysis, and dissemination efforts are published and available to the general public. Agencies conduct annual data user meetings to inform users about procedures for collecting and analyzing data and to receive feedback about the quantity and quality of information provided. The Department has also periodically provided for comprehensive outside review of the scope, methodology, and quality of data collection and analysis.

In spite of on-going efforts to maintain the quality of information provided and the transparency of the methodology used, misunderstanding, concerns, or complaints about the information provided periodically arise (e.g., USDA/ESRP, 1985; Good and

[1] See Kunze (1990) and Allen (1994) for excellent reviews of the history of public situation and outlook programs in the U.S.

Irwin, 2011). More recently (since 2006) those concerns have centered on the accuracy of the quarterly estimates of corn inventories and to a lesser extent on the methodology and accuracy of early season yield forecasts (e.g., Polansek, 2010; Pleven and McGinty, 2011). The issues raised highlight the importance of continuous internal and external review of the methodology and procedures used in USDA estimation and forecasting programs. It is in that context that this review of forecast and estimation procedures and performance for corn and soybeans has been conducted. Please note that the review is targeted, and therefore, not comprehensive. Specifically, this report focuses on evaluation of the procedures for and performance of:

(1) National corn and soybean yield forecasts presented in the May, June, and July *World Agricultural Supply and Demand Estimates* report provided by the WAOB,

(2) National corn and soybean yield and production forecasts in the August, September, October, and November *Crop Production* reports provided by NASS, and

(3) National corn and soybean stocks estimates provided in the December, March, June, and September quarterly *Grain Stocks* reports provided by NASS.

The period of performance evaluation generally spans the 1990-91 through 2012-13 crop production and marketing years. WASDE yield forecasts were first reported in 1993. This report provides limited background description of survey, forecasting, and estimation procedures since those procedures are fully described in Agency documents and other academic publications (e.g., Good and Irwin, 2011; Adjemian, 2012). The report focuses instead on an evaluation of the accuracy of yield and production forecasts and on measures of “surprises” in quarterly stocks estimates. The review also includes a brief discussion of some of the issues created by the discontinuation of the Census Bureau’s M311J report *Fats and Oils: Oilseed Crushings* after July 2011. The following sections of the report are organized around each of these four topics, followed by a recommendations section.

In addition to the quantitative analysis of forecasts that form the core of this report, we also thoroughly reviewed USDA survey forms for the reports in question and held numerous in-depth discussions with USDA officials, industry analysts, and farmers. These interviews helped shape our interpretation of the quantitative results and the development of final recommendations.

USDA Forecasting System

USDA corn and soybean forecasts are a product of the joint effort of various agencies within the USDA (Spilka, 1983; Vogel and Bange, 1999; Lusk, 2013). The end result of the process is production of commodity-by-commodity and country-by-country (selected countries) marketing year balance sheets of supply, consumption, and stocks. The estimates are released in monthly World Agricultural Supply and Demand Estimates (WASDE) reports. Supply for a particular crop year consists of carryover stocks from the previous year, production during the current year, and imports during the current year. Projections of consumption include domestic use, exports, and year-ending stocks. For the U.S. corn and soybean crops (and other domestic crops) the balance sheet contains a projection of marketing year average farm price—typically projected in a range. From May through July prior to harvest, the projection of domestic production is based on National Agricultural Statistics Service (NASS) estimates of planted acreage intentions and expert judgment about potential average yield. Trend yield analysis, planting progress, and crop weather models provide input for the average yield projection during these months. From August forward, NASS production estimates (harvested acreage × yield) are used in the balance sheet.

Consumption forecasts are based on a wide array of information sources and analytical techniques. Foreign production estimates, which impact export prospects, rely on weather analysis, agricultural attaché reports, satellite imagery, and other public and private information sources. Specific projections of consumption by category are based on historical patterns of consumption, formal demand models, and expert judgment. The price projection reflects a simultaneous consideration of supply, consumption, and stocks. Historical prices play an important role in the evaluation process.

The development of the balance sheets occurs in a monthly meeting of the Interagency Commodity Estimates Committees, involving analysts from the World Agricultural Outlook Board, the Economic Research Service, the Foreign Agricultural Service, the Agricultural Marketing Service, and the Farm Service Agency. Consensus forecasts are developed based on interaction among the analysts. Each month, the process is repeated and appropriate revisions are made based on new information about supply and consumption. Once the marketing year begins, analysts make use of current data available from USDA weekly export reports, NASS stock reports, Bureau of Census reports of processing and exports, and other public and private sources to adjust the projections of consumption for the year.

Related Literature

One strand of the academic literature on situation and outlook information investigates theoretical conditions necessary for USDA forecasts to improve economic welfare. The earliest work assumes cobweb (backward-looking) price expectations, which results in market participants making systematic forecasting errors (Smyth, 1973; Freebairn, 1976a, 1976b, 1978). These errors cause a misallocation of resources, and hence, USDA forecasts improve social welfare by providing market participants with forward-looking forecasts. Later work assumes that market participants have rational expectations, whereby participants use all available information when making forecasts and do not make systematic forecasting mistakes (Muth, 1961). More formally, market participants' subjective expectations are the same as the “true” underlying economic model. This leads to the well-known efficient market result that prices reflect all available information. In this case, outlook forecasts are redundant. Social welfare cannot be increased by providing market participants with “better” forecasts, as the participants already make fully rational forecasts. However, the rational expectations model is based on two rather restrictive assumptions. First, market participants are assumed to know the true underlying parameters of market supply and demand. The mechanism by which they learn the parameters is not specified. Second, market participants incur no costs as they gather and analyze information in the process of forming expectations.

More recent work incorporates learning and costly information into rational expectation models (e.g., Stein, 1992a, 1992b). Under these assumptions, a rational expectations equilibrium cannot be reached instantaneously, and instead, economic welfare is associated with how quickly the market approaches the true equilibrium. Irwin (1997) argues that USDA forecasts may improve the speed at which markets approach equilibrium (fundamental value) in two ways. First, USDA forecasts can increase the number of informed market participants that employ more sophisticated forms of learning. This is consistent with the long-held view that a core function of public situation and outlook programs is economic education (e.g., Benedict, 1953; Kunze, 1990). Second, the USDA may be able to collect information more inexpensively than private firms due to economies of size or lower marginal costs of sampling. For example, if market participants believe a government agency collects and disseminates information objectively, then market participants may be willing to more freely divulge information. A private firm seeking the same information for private gain may have to pay a substantial premium to market participants in order to obtain the information. Irwin (1997) also argues that USDA forecasts should be more valuable in periods with high market uncertainty since the speed of convergence to equilibrium tends to be slower under these circumstances. This point is helpful in understanding concerns about USDA corn and soybean forecasts in recent years.

Another strand of the literature relaxes the assumption of perfect competition in agricultural markets (e.g., Kyle, 1984). In this framework, USDA forecasts “level the playing field” and cause markets to become more competitive. Social benefits may be present because the imperfectly competitive equilibrium converges towards the perfectly competitive equilibrium. In other words, the equilibrium price becomes more informative with public information. This result is consistent with the view expressed by Surls and Gajewski (1990), “If all forecasting were left to private firms, small players could be left in the cold. USDA’s forecasts make objective information available to all market participants at the same time.” (p. 5)

A limited number of previous studies provide empirical estimates of the direct welfare benefits of USDA forecasts (Hayami and Peterson, 1972; Freebairn, 1976a; Bradford and Kelejian, 1978; Antonovitz and Roe, 1984; McNulty, 1997). In these studies, a theoretical supply/demand structure for a market is proposed, parameter estimates are obtained, and then social welfare is estimated under different information or expectation assumptions. As a group, these empirical studies suggest the social welfare value of USDA forecasts substantially exceeds the cost. A much larger number of studies investigate the indirect welfare benefits of USDA forecasts by analyzing the reaction of market prices after the release of the forecasts or by evaluating the accuracy of the forecasts themselves. Several dozen previous studies examine price reaction to the release of USDA forecasts for a variety of commodities (e.g., Sumner and Mueller, 1989; Colling and Irwin, 1990; Garcia et al., 1997; Isengildina-Massa et al., 2008; Adjemian, 2012), with nearly all finding a significant price reaction. This suggests USDA forecasts generate economic welfare benefits because market participants’ assessments of supply and demand conditions change as a result of release of the forecasts. The evidence is only suggestive, however, because the cost of producing USDA forecasts is not considered.

Numerous previous studies investigate the accuracy of USDA forecasts using a variety of tests and procedures (e.g., Just and Rausser, 1981; Allen, 1994; Sanders and Manfredo, 2003, 2005; Isengildina, Irwin, and Good, 2006; Colino and Irwin, 2010; Isengildina-Massa, Karali, and Irwin, 2013). Results of these studies are mixed, with USDA forecasts sometimes failing tests of forecast efficiency and rationality. The evaluation of USDA corn and soybean forecasts and estimates in following sections of this report is most closely related to the previous literature on the accuracy of USDA forecasts.[2]

[2] See Lusk (2013) for further discussion about the economic value of USDA reports and prioritizing data collection and reporting.

WAOB Corn and Soybean Yield Forecasts

WAOB Yield Forecast Methodology

The corn and soybean yield forecasting methodology used by the WAOB for yield forecasts presented in the May, June, and July WASDE reports has varied over time, but has relied heavily on trend yield analysis. The May 1993 report, for example, stated that for corn "Projected yield is derived from a simple linear trend fit over 1960-92 period" and for soybeans, "Projected yield based on 1972-92 regional trends weighted by acres." The trend-only methodology was modified over time so that the May 2012 report stated that for corn "Projected corn yield based on the simple linear trend of the national average yield for 1990-2010 adjusted for 2012 planting progress." In the same report, the soybean yield estimate is described simply as "projected yields based on 1989-2010 trend analysis." Notice that the projection for the 2012 corn yield excluded the 2011 yield observation and that the period included in the analysis was much shorter than in 1993. These assumptions were somewhat controversial at the time (Irwin and Good, 2012a).

As the crop season advances, the WAOB has occasionally made changes to the yield forecast based on weather or crop conditions. For example, as drought conditions developed in the 2012 growing season, the WAOB lowered the projected U.S. average corn yield by 20 bushels per acre with the following comments: "Projected corn yield lowered to reflect expected impacts of persistent and extreme June and early July dryness and heat across the central and eastern Corn Belt." So, while the exact method varied somewhat from year-to-year, the basic methodology remained one of trend yield analysis plus an adjustment for current year conditions, plus an adjustment for timeliness of corn planting. A more substantial change was apparently made in 2013 as reflected by the following statements in the May 2013 WASDE report. For corn, "Projected yield based on a weather adjusted trend, lowered to reflect the asymmetric yield response to July precipitation and the slow pace of planting progress as of early May" and for soybeans, "Projected yields based on 1988-2012 trend analysis adjusted for weather during the growing season." To the best our knowledge, the explicit use of a crop weather regression model (Westcott and Jewison, 2013) had not been previously acknowledged.[3]

WAOB Yield Forecast Errors

The WAOB yield forecasts have been subject to criticism from time to time, because of changing methodology, perceived inappropriate period for calculating trend, or lack of

[3] See Tannura, Irwin, and Good (2008) for a review of crop weather regression models.

sensitivity to other potential yield indicators such as crop conditions. The authors are also aware that some criticism of the yield forecasts reflects a lack of understanding of the forecasting methodology. In particular, some data users don't appear to be aware of the difference between the WOAB forecasting methodology and that of NASS as reflected in the *Crop Production* reports issued later in the growing season. NASS corn and soybean forecasts are based on a large-scale survey procedure, while, as noted above, WAOB forecasts are based on statistical modeling of trends with some other adjustments.

To evaluate the historic accuracy of the WAOB yield forecasts, the May, June, and July, forecasts are compared to the final yield estimate released by NASS in the *Annual Crop Production* report in January following harvest. The differences between the monthly forecasts and the final estimates in bushels per acre over 1993-2012 are presented in Tables 1 and 2 for corn and soybeans, respectively. The $\textit{WAOB Bushel Error}_{m,t}$ for the forecast made in month *m* of crop year *t* is calculated as:

(1) $$\textit{WAOB Bushel Error}_{m,t} = (\textit{Actual}_t - \textit{WAOB Forecast}_{m,t})$$

where $\textit{Actual}_t$ denotes the realized final U.S. average yield in crop year *t* and $\textit{WAOB Forecast}_{m,t}$ is the forecasted U.S average yield for crop year *t* made in month *m* (May, June, or July).[4] For the present purposes, the crop year is assumed to start in May of the calendar year of harvest and continue through January of the calendar year after harvest. The differences between the monthly forecasts and the final estimates in percentages are presented in Figures 1-3 for corn and Figures 4-6 for soybeans. The $\textit{WAOB Percent Error}_{m,t}$ for the forecast made in month *m* of crop year *t* is calculated as:

(2) $$\textit{WAOB Percent Error}_{m,t} = 100 \times (\textit{Actual}_t - \textit{WAOB Forecast}_{m,t})/\textit{Actual}_t$$

where $\textit{Actual}_t$ and $\textit{WAOB Forecast}_{m,t}$ are defined as before. When interpreting the errors computed according to equations (1) and (2), note that a positive error implies an underestimate on the part of WAOB and a negative error implies an overestimate. The tables and figures show that bushel and percentage errors associated with the WAOB corn and soybean yield forecasts are occasionally very large, such as 1993 and 2012. Large errors in these years are not surprising due to the unusual weather events that occurred during the summer (floods in July 1993 and drought in July-August 2012). In addition, there is not an obvious upward or downward bias or trend in the size of forecast errors over time. Corn forecast errors since 2006 generally are well within the historical range of errors, with the exception of May and June 2012.

Statistical analysis of the WAOB yield forecasts is based on the percent error as defined above in equation (2) since errors in percentage form are normalized for the increasing

[4] The final yield referenced here is the NASS estimate released in January after harvest.

level of corn and soybean yields over time. The average percent errors for the WAOB corn yield forecasts are shown in Table 3, with 1993-2012 broken into two sub-periods: 1993-2000 and 2001-2012. The forecasts are tested for bias with a *t*-test that the average percent error equals zero. As shown in Table 3, the WAOB forecasts consistently have a negative average error in the range of one to three percent, which indicates that the WAOB forecasts are slightly too high (over-estimates). However, the average errors are not statistically different from zero at the five percent level and the tendency towards over-estimation in the second half of the sample disappears almost entirely if 2012 is omitted.[5] While large forecast errors are expected and have occurred, the results confirm that the forecasts generally have not been biased.

The WAOB corn yield forecasts are tested for accuracy changes through time by examining the absolute percent errors in Table 4. Over the entire sample, the absolute percent errors in corn averaged 6.40 percent, 6.28 percent, and 5.28 percent in May, June, and July, respectively. The improvement in accuracy from May to July suggests that the WAOB's adjustment for current conditions helps to improve the forecasts compared to a static trend forecast. The sample is again split into sub-periods, 1993-2000 and 2001-2012, and a *t*-test for a difference in means between the two periods is calculated. None of the *t*-statistics are statistically significant and there is no evidence that the forecast accuracy differs across the time periods. Changes through time are also examined by regressing the absolute percent errors against a constant and a linear time trend:

$$(3) \qquad |WAOB\ Percent\ Error_{m,t}| = \alpha + \beta Trend_t + e_t$$

where $Trend_t$ is a time trend variable for crop year t that takes a value of 1 in 1993, 2 in 1994, and so on and e_t is a standard, normal error term. If the WAOB forecasts are improving through time, then the estimated β coefficient will be negative. Likewise, a positive estimated β would suggest that the absolute percent errors are getting larger through time or the forecasts are becoming less accurate. The estimated coefficients on the time trend and the corresponding *t*-tests that the coefficients are zero are also reported in Table 4. While all of the estimated coefficients are positive, none of them are statistically different from zero. Again, there is no compelling statistical evidence that the errors associated with the WAOB corn yield forecasts have increased in a systematic fashion. This corroborates the lack of trend observed in Figures 1-3.

An analogous set of statistics are calculated for the WAOB soybean yield forecasts. The soybean tests are presented in Tables 5 and 6. As shown in Table 5, the WOAB soybean forecasts have a tendency towards over-estimation of about one to two

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[5] The lack of statistical significance is not surprising given the small sample sizes for the sub-periods.

percent. However, as found with the corn results, the soybean yield forecasts do not produce a statistically significant bias in any subsample and the bias in the second half of the sample is heavily influenced by 2003 when there was a widespread problem with aphids. Table 6 presents the average absolute percent errors for WAOB soybean yield forecasts. It is clear that the absolute errors decline from May (5.55 percent) to July (4.83 percent) as the WAOB incorporates weather, planting progress, and/or crop conditions into the forecast. The average absolute error is uniformly smaller in the second sub-period from 2001-2012 for the May, June, and July forecasts. Likewise, the estimated trend coefficient is negative—suggesting that the absolute forecast errors have generally gotten smaller over the 1993-2012 sample. While the data suggest that the WAOB soybean yield forecasts have improved through time, none of the calculated measures are statistically significant. Finally, comparison of Tables 4 and 6 reveals that average absolute percent errors for WAOB soybean forecasts are always smaller than percent errors for WAOB corn forecasts in the same month, in some cases by as much as one percentage point. This is not terribly surprising since corn yield is thought to be more sensitive to extremes of summer precipitation and temperature than soybean yield, and hence, corn yield is the more difficult to forecast.

Taken as a whole, the evidence suggests that WAOB corn and soybean yield forecasts made in May, June, or July do not have a substantial bias. The accuracy of the forecasts also has not changed markedly over the 1993-2012 time period for either corn or soybeans. With a few exceptions, WAOB corn and soybean forecast errors since 2006 generally are within the historical range of errors. While there are instances of large forecast errors, these are readily explained by unusual weather conditions or insect problems that occurred after the forecasts were released.

NASS Corn and Soybean Yield Forecasts

NASS Yield Forecast Methodology

In each month from August through November, NASS makes corn and soybean yield and production forecasts.[6] Two types of surveys are used to collect data for the monthly NASS production forecasts and these are referred to as the *Agricultural Yield Survey* (or the farmer-reported survey) and the *Objective Yield Survey* (or the field measurement survey). Data for the final estimates released in January are collected in the December *Agricultural Survey* in which respondents report actual acres harvested and the actual yield or production.

[6] The description of the NASS yield forecasting process is largely drawn from Good and Irwin (2013).

The sample of farm operations for the *Agricultural Yield Survey (AYS)* is drawn from those who responded to the survey of planted acreage in June. The sampling design to select the operations to be surveyed uses multiple control items, such as number and type of commodities planted and desired sample size for each commodity, to determine the probability of selecting a particular operation. The same operations are interviewed each month from August through November. Most of the survey data are collected in electronic form using computer-assisted telephone interviewing. Each state in the survey is expected to achieve a minimum response rate of 80 percent.

The monthly AYS data are reviewed for consistency with previous surveys for the individual respondents and an across-record review is conducted to identify any extreme values that need to be re-checked. A summary program which accounts for sampling weights and includes an adjustment for non-respondents is used to generate an indication of expected average yield for Agricultural Statistics Districts (regions within states) and for each state surveyed. The yield indications from the survey reflect the judgment of respondents (farmers) and historical relationships indicate that respondents tend to be conservative in estimating final yields (underestimate yield potential) particularly under drought conditions (Nandram, Berg, and Barboza, 2013). This tendency is quantified and factored into the official yield forecasts.

The Objective Yield Survey (OYS) is designed to generate yield forecasts based on actual plant counts and measurements, eliminating some of the biases associated with the farmer reported yields. The sample of fields selected for the OYS survey is selected from farms that reported corn (soybeans) planted or to be planted in the June survey of acreage. Records from the June survey are sorted by state, district, county, segment, tract, crop, and field. A random sample of fields is drawn with the probability of selection of any particular field being proportional to the size of the tract. Two counting areas, or plots, are randomly selected in each field. Objective measurements (such as counts of plants, ears, and pods) are made for each plot each month during the survey cycle. When mature, the plots are harvested and yield is calculated based on actual production minus an allowance for harvest loss. Enumerators count all fruit and fruiting positions in corn and, if ears have formed, a sample of ears is measured for length and circumference. Just before the field is harvested, both plots are hand harvested and weighed by the enumerator. Four ears are sent to the NASS lab for shelling and measurement of moisture. These data are used to compute gross yield at 15.5 percent moisture. At maturity, the gross yield of soybeans is calculated as the number of pods with beans per 18 square feet times bean weight per pod and then converted to bushels per acre. Harvest loss for both crops is measured in separate units near the yield plots.

Prior to maturity and harvest, the OYS corn yield is forecast based on the forecast of the number of ears, the forecast of the weight per ear, and the forecast of harvest loss. The soybean yield forecast requires a forecast of the number of plants per 18 square feet, the number of pods with beans per plant, and bean weight per pod. Forecasts are based on conditions as of the survey date and projected assuming normal weather conditions for the remainder of the growing season. The state average gross yield for the OYS is the simple average of the gross yields for all the sample fields. In addition, a state yield forecast is also made by first averaging the forecast or actual yield factors (such as stalk counts, ear counts, and ear weight for corn and pod counts and pod weights for soybeans) and then forecasting the state average yield directly from these averages. This forecast is based on a regression analysis of the historical relationship (15 years) between the yield factors and the state average yield. Historical relationships indicate that OYS yield indications tend to over-estimate yield potential when estimating final yields (Nandram, Berg, and Barboza, 2013). This tendency is quantified and factored into the official yield forecasts.

The survey and forecasting procedures described here produce a number of indictors of the net yield of corn and soybeans. In August these indicators include: i) average field level yields from the OYS, ii) average state level counts from the OYS, and iii) the average yield reported by farm operators in the AYS. After harvest begins, yields reported by farmers are also included as an indicator of final yield. Each of the indicators results in a point yield forecast for which forecast errors are computed based on the historical relationships between forecasts and actual yield. The range of yields is evaluated relative to all of the pieces of available data to assist in the selection of the official yield forecast.[7] This process is completed independently in each state and at the

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[7] To the best of our knowledge, Nandram, Berg, and Barboza (2013) provide the only public documentation of the biases in the AYS and OYS surveys. The following discussion of the biases for corn is revealing (note: DAS stands for the December Agricultural Survey):

> "The OYS and AYS indications are biased estimators of the true final yields. The potential reasons for the biases differ for the two surveys. One possible reason for the bias of the OYS indications is that the measurement process leads to a systematic overestimation of the plant density in a field. Two potential reasons for the biases in the AYS indications are pessimism on behalf of the farmers and exclusion of farms in the largest size stratum from the sampling frame. Large farms are conjectured to have higher average yields than moderately sized farms because of greater investment in advanced technology. Crude estimates of the average biases of the OYS (or AYS) indications are the differences between the average of the OYS (or AYS) indications for a particular month and the average of the DAS indications, where the average is across states and years for which data are available. The average differences between the OYS indications and the DAS indications are respectively 13.96, 11.62, 13.13, 14.99 and 14.97 for August, September, October, November and December. The average differences between the AYS indications and the DAS indications are respectively −12.26, −13.42, −9.81, and −4.10 for August, September, October, and November. The OYS biases are approximately constant across the months, while the AYS biases are smaller in magnitude for October and November than for August and September." (page numbers not provided in online version)

national level. A formal Agricultural Statistics Board (ASB) consisting of 7 to 10 statisticians is convened to review regional yield indicators and determine an official yield forecast. Final yield estimates for each crop, reflecting data collected in the December *Agricultural Survey*, are released by NASS in the *Annual Crop Production* report in January following harvest.

NASS Yield Forecast Errors

Like the WAOB yield forecasts, the NASS corn and soybean yield forecasts have been subject to periodic criticism about lack of accuracy (e.g., Polansek, 2010). To evaluate the historic accuracy of the NASS yield forecasts, the August, September, October, and November forecasts are compared to the final yield estimate released in January. The differences between the monthly forecasts and the final estimates in bushels per acre over 1990-2012 are presented in Tables 7 and 8 for corn and soybeans, respectively. The $NASS\ Bushel\ Error_{m,t}$ for the forecast made in month *m* of crop year *t* is calculated as:

(4) $$NASS\ Bushel\ Error_{m,t} = (Actual_t - NASS\ Forecast_{m,t})$$

where $Actual_t$ denotes the realized final U.S. average yield in crop year *t* and $NASS\ Forecast_{m,t}$ is the forecasted U.S. average yield for crop year *t* made in month *m* (August, September, October, or November).[8] As before, the crop year is assumed to start in May of the calendar year of harvest and continue through January of the calendar year after harvest. The differences between the monthly forecasts and the final estimates in percentages over 1990-2012 are presented in Figures 7-10 for corn and Figures 11-14 in soybeans. The $NASS\ Percent\ Error_{m,t}$ for the forecast made in month *m* of crop year *t* is calculated as:

(5) $$NASS\ Percent\ Error_{m,t} = 100 \times (Actual_t - NASS\ Forecast_{m,t})/Actual_t$$

where $Actual_t$ and $NASS\ Forecast_{m,t}$ are defined as before. When interpreting the errors computed according to equations (4) and (5), note that a positive error implies an underestimate on the part of NASS and a negative error implies an overestimate. Like WAOB forecasts, errors associated with the NASS yield forecasts are occasionally very

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Unfortunately, neither the time period for the computations nor the units for the differences are reported by the authors. Regardless of the units, the magnitude of the differences will probably strike most observers as surprisingly large. Equally important, notice that the differences are of opposite sign for the OYS and AYS, which means that the differences tend to cancel out when the forecasts from the two surveys are combined to form official forecasts.

[8] The final yield referenced here is the NASS estimate released in January after harvest.

large, such as 1993 and 1995 in corn and 2003 and 2012 in soybeans. Again, these examples of large errors are not surprising due to the unusual weather events. It is interesting to note that NASS corn yield forecast errors in 2012 were extremely small, which is surprising given the magnitude of drought conditions that prevailed in 2012 (Irwin and Good, 2012b). The figures suggest a downward trend in corn errors over time, but no trend in soybean forecast errors. Corn forecast errors since 2006 are well within the historical range of errors. Soybean forecast errors since 2006 are also within the historical range, except for September and October 2012. However, there is also a general tendency for soybean forecasts to be conservative, in the sense of underestimating the final yield. This is most pronounced over 2004-2012, when about two-thirds of the forecasts across all four months under-estimated final yield.

Similar to the procedures used to evaluate the WAOB corn and soybean yield forecasts, the NASS yield forecasts are examined for both bias and changes in accuracy through time. The average percent errors for each forecast month in corn for the entire sample period and for sub-samples formed from 1990-2000 and 2001-2012 are presented in Table 9. The average error calculations presented in Table 9 reveal no consistent patterns in the magnitude of the average errors and reveal no bias in the forecasts. The smallest average error was 0.06 percent for the October forecast in 1990-2000 and the largest average error was 0.68 percent for the September forecast in 2001-2012. No statistically significant bias estimates were found across months or sub-samples.

Table 10 presents the average absolute errors in the corn yield forecasts for each month and sample period. As expected, the average absolute percent error declines as the growing season moves from pre-harvest through harvest. For the entire sample period, for example, the absolute error averaged 4.25 percent for the August forecast and only 0.73 percent for the November forecast. Examining the two sub-samples, the absolute percent errors were smaller in 2001-2012 for every forecast month except November, where the average errors were nearly identical. The decline in the October absolute forecast error is marginally statistically significant with a p-value of 0.10. Changes through time are also examined by regressing the absolute percent errors against a constant and a linear time trend:

$$(6) \qquad |NASS\ Percent\ Error_{m,t}| = \alpha + \beta Trend_t + e_t$$

where $Trend_t$ is a time trend variable for crop year t that takes a value of 1 in 1990, 2 in 1991, and so on and e_t is a standard, normal error term. The estimated trend coefficients are negative for the August, September, and October yield forecasts. The estimated coefficients for both September and October are statistically different from zero (5 percent level), indicating that the forecast errors trended lower over the 1990-

2012 time period.[9] For example, the absolute percent error associated with the September forecasts declined by an average of 0.18 percent per year over this period. The results provide convincing evidence that the NASS corn yield estimates have improved through time, in the sense of absolute forecast accuracy.

The NASS soybean yield forecasts are also tested for bias and changes in accuracy through time. As shown in Table 11, the NASS soybean yield forecasts have a consistent downward bias in nearly all forecast months and subsamples. For example, the October yield forecast was on average too low by 0.88 percent from 1990-2000 and 1.24 percent too low from 2001-2012. The bias (1.07 percent) across the entire sample period is statistically different from zero at the 5 percent level. A statistically significant bias is also found in the November yield forecasts. The August and September forecasts are downward biased, but not statistically different from zero. The results show a clear statistical tendency for NASS to under-estimate soybean yield. The magnitude of the downward bias, while not large is also non-negligible. For example, the 2.45 percent downward bias in September soybean forecasts over 2001-2012 is 1.1 bushels when stated on a bushels per acre basis.

The absolute percentage errors for soybean yield forecasts are presented in Table 12. As with corn forecasts, the average absolute percent error declines as the growing season moves from pre-harvest through harvest. For the entire sample period, for example, the absolute error averaged 5.15 percent for the August forecast and only 0.77 percent for the November forecast. There is not a uniform tendency for errors to get either bigger or smaller over the sample period. For the two subsamples, the average absolute percent error increased for the August and November forecasts, but declined for the September and October forecasts. The difference in the average absolute error for the sub-periods was not statistically different from zero for any month. The estimated coefficients on the trend variable show some tendency for declining errors over time across all months. For example, the October absolute percent error declined by 0.06 percent per year on average; but, it was not a statistically significant trend. Generally, there is not strong evidence that NASS soybean yield forecast accuracy has changed through time. There is one other notable finding for soybeans. Comparison of Tables 10 and 12 shows that absolute percent errors for NASS soybean forecasts are generally larger than absolute percent errors for NASS corn forecasts in the same month, just the opposite of what was found for WAOB forecasts. Furthermore, NASS soybean errors in 2001-2012 were larger than corn errors for each of the four months, with a difference of over two percentage points in August. This may at least partially reflect the fact that the critical growing period in the U.S. occurs later for soybeans than corn. It may also be evidence that the NASS forecast methodology for soybeans can be improved, particularly for August and September forecasts.

[9] The downtrend in percentage errors is statistically significant even if 2012 is dropped from the sample.

Additional perspective on NASS yield forecasting performance can be gained by comparing the pattern of WAOB and NASS forecast errors across the growing season for the same crop. NASS yield forecasts should be more accurate than WAOB forecasts because NASS forecasts are made later in the growing season when more is known about the condition of crops and NASS uses a much more costly and large-scale survey methodology to directly assess yield. Tables 13 and 14 show the average absolute errors for WAOB and NASS corn and soybean forecasts, respectively, over 1993-2012. This is the time period of maximum overlap between the two sets of forecasts. The results are not surprising for corn, as there is a roughly linear decline in average absolute forecast errors moving from May to October and a sharp drop in November once much of the crop has been harvested. For the entire sample period, the August NASS absolute error was about two percentage points smaller than the WAOB May absolute error. There is one exception to the pattern. Over 1993-2000, the absolute error for August NASS forecasts exceeded that of the July WAOB forecasts. The patterns are much more puzzling for soybeans, where the NASS absolute error in August for the entire sample period, 5.09 percent, was larger than the WAOB absolute error in July, 4.83 percent, and only about a half a percentage point smaller than the WAOB May absolute error. The comparisons are even more stark over 2001-2012, when the NASS August absolute error substantially exceeds the WOAB July absolute error and is essentially the same as the WAOB absolute errors for May and June.

In sum, the NASS yield forecasts for corn reveal no evidence of bias in any month and forecast errors since 2006 are well within the historical range of errors. There is some evidence of improvement in the accuracy of NASS corn yield forecasts over time. Soybean forecast errors since 2006 are also within the historical range, except for September and October 2012, and there is no statistical change in the magnitude of forecast errors for soybean yields through time. However, there is also a general tendency for soybean forecasts to be conservative, in the sense of underestimating the final yield. The downward bias is statistically significant in October and November for the entire sample period and especially pronounced in 2004-2012, when about two-thirds of the forecasts across all four months under-estimated final yield. The magnitude of the downward bias, while not large is also non-negligible. The results indicate that the NASS soybean forecasting methodology may not have performed as well as might be expected in recent years.

Market Surprises for NASS Production Forecasts

Some of the criticism of NASS corn and soybean forecasts stems from perceptions that, rather than a problem with absolute accuracy, the issue is that the forecasts differ substantially from market expectations. Consequently, we also examine the history of the NASS monthly corn and soybean production (rather than yield) forecasts relative to pre-release forecasts by private sector analysts. Production forecasts are used in the analysis rather than yield forecasts due to the limited time period for which analyst yield forecasts are available. Good and Irwin (2006) show that the vast majority of variation in NASS corn and soybean production forecasts is due to variation in yield forecasts, rather than harvested acreage forecasts, and hence, little information is lost by using production forecasts instead of yield forecasts.

Market analyst forecasts ("average trade guesses") for the NASS August, September, October, and November corn and soybean production forecasts as well as the January production estimates were assembled for the 1990-2012 period. The average analyst forecast is represented by a simple average of the pre-report forecasts made by Informa Economics (formerly Sparks Commodities) and Conrad Leslie for 1990-2000. The average analyst forecast for 2001-2005 is represented by the simple average of the Informa Economics estimate and the average analyst estimate reported by the Dow Jones Newswire survey. The Dow Jones survey average is used over 2006-2012.[10]

The difference between the NASS forecast and the average analyst forecast is referred to as the "market surprise" and presented in terms of millions of bushels in Tables 15 and 16 for corn and soybeans, respectively, over 1990-2012.[11] The $\textit{Bushel Surprise}_{m,t}$ for the forecast made in month m of crop year t is calculated as:

(7) $$\textit{Bushel Surprise}_{m,t} = (\textit{NASS Forecast}_{m,t} - \textit{Analyst}_{m,t})$$

where $\textit{Analyst}_{m,t}$ is the average analyst forecasted U.S. production for crop year t made in month m (August, September, October, or November) and the other variables are defined as before. The differences between the NASS forecasts and the average analyst forecasts in percentages are presented in Figures 15-19 for corn and Figures 20-24 for soybeans. The $\textit{Percent Surprise}_{m,t}$ for the forecast made in month m of crop year t is calculated as:

(8) $$\textit{Percent Surprise}_{m,t} = 100 \times (\textit{NASS Forecast}_{m,t} - \textit{Analyst}_{m,t})/\textit{NASS Forecast}_{m,t}$$

where all variables are defined as before. When interpreting the surprises computed according to equations (7) and (8), note that a positive surprise implies an underestimate relative to NASS on the part of market analysts and a negative surprise implies an overestimate. In general, market analysts are able to anticipate NASS corn and soybean production forecasts reasonably well, typically within about +/-two

[10] See Good and Irwin (2006) for further details on the pre-release analyst forecasts for corn and soybeans.

[11] See Eglekraut et al. (2003) and Good and Irwin (2006) for a detailed analysis of corn and soybean market surprises and the relative accuracy of NASS and private market analysts since 1970.

percentage points. There are of course examples of large surprises, such as corn in September 2012 and soybeans in November 2012. Market surprises for August soybeans show a marked tendency in recent years towards negative values, indicating that market analysts over-estimate NASS production forecasts. Highlighting this pattern, there was only one year with a positive surprise for August soybeans since 2001. Market surprises for NASS September forecasts also showed this tendency.

The average percent surprise for NASS corn production forecasts is shown in Table 17. The 1990-2012 sample is again broken into two sub-periods: 1990-2000 and 2001-2012. The analyst surprises are tested for bias by using a *t*-test for the average percent surprise equaling zero. The analysts surveyed do not consistently under- or over-estimate the NASS production forecast for corn. Only the average percent error for September in 2001-2012 is statistically different from zero at the five percent level. Analysts consistently guessed too low relative to the NASS September corn production forecast during that period.

The absolute percent surprises for the analysts are presented in Table 18. As expected, the difference between the analyst production forecasts and the NASS forecasts decline from August through November. The average absolute percent surprise in August is 1.77 percent for the entire sample period, but for November the average percent error is only 0.56 percent. Oddly, the size of the surprises actually increases in January, to 0.74 percent for the entire sample period. Across the two sub-periods, there is not a consistent tendency for the market surprise to either increase or decrease. The August, September, and November surprises are smaller in the later sub-period while the October and January surprises are larger. The test of differences in means across the two sub-periods does not reveal any differences that are statistically significant at the five percent level. Changes in the magnitude of surprises through time are also tested by regressing the absolute percentage surprise in the analyst forecasts against a time trend:

$$(9) \qquad |Percent\ Surprise_{m,t}| = \alpha + \beta Trend_t + e_t$$

where $Trend_t$ is a time trend variable for crop year t that takes a value of 1 in 1990, 2 in 1991, and so on and e_t is a standard, normal error term. The coefficient on the time trend (β) and the corresponding *t*-test that the coefficient is zero are reported in Table 18. Consistent with the difference in means tests, the August, September, and November surprises show a downward trend in the absolute level of surprises, while October and January show a positive trend coefficient. None of the estimated trend coefficients are different from zero at the five percent level. In summary, the average market surprise for corn production reveals no systematic bias nor is there evidence that the magnitude of the surprises have changed substantially through time.

Market surprises for soybean production are examined in parallel fashion. The tests for bias are presented in Table 19 and the average absolute percent surprises are shown in Table 20. As revealed in Table 19, there is a general pattern of positive bias (under-estimation) during the first half of the sample and negative bias (over-estimation) in the second half. Given this pattern, it is not surprising that there is no evidence of a uniform bias in the market surprises across the entire sample. There are two statistically significant incidences of bias. First, analysts consistently under-estimated the NASS September soybean production forecast in 1990-2000. Second, analysts show a statistically significant over-estimation of the NASS August soybean production forecast in the more recent period, 2001-2012, by about two percentage points.

Table 20 shows that the absolute percentage surprise decreases from August (1.99 percent) to November (0.86 percent), but increases again in January (0.93 percent). The average absolute surprise for soybeans over the entire sample period is comparable to the averages for corn. The magnitude of the absolute surprise increases from the 1990-2000 period to the 2001-2012 for all months; although, the difference in means is not statistically significant at conventional levels. Likewise, the estimated coefficient on the time trend variable is positive—but not statistically significant—for all months except January. So, the surprises show some tendency to get larger over the sample, particularly in August and September, but the increase is not statistically significant.

In summary, market surprises for soybean production exhibit a general pattern of positive bias (under-estimation) during the first half of the sample and negative bias (over-estimation) in the second half. The magnitude of the over-estimation bias in the second half of the sample is large and statistically significant in August.

The data on market analyst pre-release expectations allows us to not only compute measures of market surprises, but to also compare the relative accuracy of NASS and market analyst corn and soybean production forecasts versus final production estimates released in January. Table 21 presents the average absolute percent errors for NASS and the market analysts in corn over 1990-2012. The differences in NASS and market analyst absolute errors year-by-year are shown in Figures 25-28. A positive difference implies that the absolute error for NASS exceeded the absolute error for market analysts and a negative difference implies that the absolute error for market analysts exceeded that of NASS. Table 21 reveals that the average absolute percent errors for NASS were smaller than for market analysts in every case except two. The advantage of NASS was statistically significant at the 10 percent level or better in five of six cases for October and November forecasts. Market analysts had a smaller average absolute percent error for the entire sample period in August, but this advantage was entirely due to performance in the first half of the sample which disappeared in the second half.

Overall, these results provide further evidence of a strong performance by NASS in forecasting corn yields.

Table 22 presents the average absolute percent errors for NASS and the market analysts in soybeans over 1990-2012. The differences in NASS and market analyst absolute errors year-by-year are shown in Figures 25-28. In general, market analyst soybean production forecasts are more accurate than NASS production forecasts in August and September. This makes sense given the earlier results that NASS soybean forecasts in these months tend to be under-estimated (conservative) and market surprises tend towards over-estimation, which implies that market analyst forecasts are closer to final estimates. While this pattern is notable, none of the differences in forecast accuracy in August or September were statistically significant. Following the results for corn, NASS soybean production forecasts for October and November were more accurate than market analyst forecasts in every comparison, with three statistically significant at the 10 percent level or better. The pattern of increasing superiority of NASS forecasts across the forecasting months is consistent with previous results reported by Eglekraut et al. (2003) and Good and Irwin (2006). Eglekraut et al. (2003, p.94) provide the following explanation for the pattern: “As harvest progresses and objective yields become relatively more precise, the value of repeated location-specific sampling procedures employed by the USDA that are designed to evaluate this component of overall yields increases.” In other words, the USDA forecasting system is best-suited to generating accurate forecasts for mature crops.

NASS Quarterly Stocks Estimates for Corn and Soybeans

NASS Stock Estimation Methodology

NASS provides estimates of U.S. corn and soybean stocks at the end of each quarter of the marketing year. The reference dates for those estimates are December 1, March 1, June 1, and September 1. Estimates of on-farm grain stocks are based on data collected in the quarterly Agricultural Surveys in which a sample of producers are asked to identify the storage capacity of all structures normally used to store whole grains or oilseeds and to estimate the total number of bushels of corn and soybeans stored on the reference date on the total acres operated by the respondent regardless of ownership or intended use of the crops. The report form does not instruct on-farm survey respondents to report the number of 56-pound bushels of corn and 60-pound bushels of soybeans. NASS apparently assumes on-farm respondents use these standards without prompting. For the December report, estimates of un-harvested production are also included in the stocks estimate. Respondents are specifically asked to estimate the number of acres and expected yield for crops remaining to be harvested for the current crop year. Respondents are also asked if the un-harvested production was included in the respondent's estimate of stocks on hand. For the September report, respondents are specifically asked to exclude any new crop inventories. Stocks estimates are imputed for non-respondents.

The sample size for the Agricultural Surveys is large in order to provide sufficient observations needed for statistical rigor when the range of potential responses is very large. In a recent survey cycle, the sample size was 96,022 in June, 65,953 in September, 82,760 in December, and 83,089 in March.[12] The sample consisted of 2,804 very large farms and 6,390 farms identified in the June Area Survey but were missing from the NASS list of farm operators. These two groups were surveyed every quarter. The rest of the sample was drawn from the NASS list of farm operators and the number and make-up of those respondents varied by quarter. The number of farm operators in this category ranged from 86,828 in June to 56,816 in September. Of the 86,828 surveyed in June, 32,328 were included in all four quarterly surveys.

For the December 2010 through June 2013 period, the breakdown of grain stocks section respondents to the quarterly Agricultural Surveys was as follows:

Zero grain stocks—49.5% to 63.7%, average 56.7%

Refused to answer or unknown stocks—21.2% to 29.1%, average 25.2%

Answered, but zero corn and soybean stocks—0.8% to 7.1%, average 3.6%

Corn stocks, but zero soybean stocks—6.1% to 10.8%, average 8.5%

Soybean stocks, but zero corn stocks—0.4% to 2.2%, average 1.2%

Both corn and soybean stocks—1.2% to 8.9%, average 4.7%

Given that the total number of respondents to this section of the Agricultural Survey ranged from 53,100 to 67,100 over this period, approximately 7,000 to 9,000 respondents reported positive on-farm corn stocks and 3,000 to 4,000 reported positive on-farm soybean stocks for a given *Grain Stocks* report. Note that these estimates are the lower bound of the total number of respondents that represent corn and soybean producers since a certain proportion of producers for any given survey reference date will have completed sales, and therefore, report zero inventories. Sample sizes in this range are typically considered adequate to estimate grain stocks with a reasonable degree of statistical accuracy.

Estimates of off-farm stocks of corn and soybeans are based on data collected in the *Grain Stocks* report from mills, elevators, warehouses, and other storage facilities. This

[12] Email communication with Joseph Prusacki of NASS, July 15, 2013.

survey is intended to be a census of all commercial facilities. Respondents are asked to identify the number of storage locations operated and being reported, the rated storage capacity of all locations being reported, and to estimate the number of bushels of corn and soybeans stored at those facilities on the reference date. The report form reminds off-farm survey respondents to report the number of 56-pound bushels of corn and 60-pound bushels of soybeans. For the September 1 report, respondents are also asked to separately estimate stocks harvested in previous crop years (old crop) and stocks harvested in the current crop year (new crop).

The survey procedures for the quarterly stocks estimates is expected to provide relatively accurate stocks estimates even though the sampling variability for the on-farm stocks estimate is relatively large for some quarters. The relative standard errors reported for the 2012 marketing year were as follows:

	Corn	Soybeans
December 1, 2012	1.7%	2.1%
March 1, 2013	2.4%	2.5%
June 1, 2013	3.1%	3.2%
September 1, 2013	4.0%	8.0%

These compare to the standard errors of 1.1% reported for both corn and soybean yield indications from the farm operator survey for the 2012 U.S. production estimates released in January 2013. However, the objective yield indications reflected in that report are also subject to sampling variability since only a sample of crop acreage is included in that survey. In contrast, the survey for the off-farm stocks estimates is a near census of commercial facilities, and therefore, estimates are not subject to sampling error.

Market Surprises for NASS Stocks Estimates

NASS estimates of quarterly stocks provide important market information regarding the magnitude of consumption during the previous quarter of the marketing year as well the supply available for future consumption. Unlike the WAOB and NASS crop production forecasts, which can be compared to a final production estimate in order to evaluate forecast accuracy, there is no independent estimate for judging the accuracy of the quarterly NASS stocks estimates. Instead, this section examines the history of the NASS quarterly corn and soybean stocks estimates relative to pre-release estimates by private sector analysts. While this type of analysis is limited due to the lack of a “final” benchmark, the history of market surprises for the stocks estimates should reveal estimates that market analysts found particularly problematic. This analysis is similar to the evaluation of analyst corn and soybean production estimates found in the previous section.

Newswires report the expected stocks estimates of various market analysts from which an average analyst estimate is computed. Using the average analyst estimates reported by the Dow Jones Newswire (or their predecessor, Oster Dow Jones and Knight Ridder), the difference from NASS stocks estimates was calculated for each quarter for the 1990 through 2012 marketing years.[13] Specifically, the $Bushel\ Surprise_{m,t}$ for the stock estimate made in quarter m of marketing year t is calculated as:

$$(10) \qquad Bushel\ Surprise_{m,t} = (NASS\ Estimate_{m,t} - Analyst_{m,t})$$

where $NASS\ Estimate_{m,t}$ is the NASS total U.S. stock estimate (on- and off-farm) for marketing year t made in quarter m (December 1, March 1, June 1, and September 1) and $Analyst_{m,t}$ is the average analyst stock estimate for marketing year t made in quarter $m.$ The marketing year in the case of stock estimates is assumed to the standard September-August marketing year. Therefore, the first stock estimate for the marketing year refers to December 1 of the calendar year of harvest and the last refers to September 1 of the calendar year after harvest. The differences in millions of bushels are presented in Table 23 for corn and Table 24 for soybeans. Differences were in both directions and in a wide range during the study period, with the largest differences generally for corn. There was also a tendency towards larger surprises in corn since 2006.

Denominating the market surprises in bushels may not represent the most useful way to examine the magnitude and pattern of market surprises for NASS grain stock estimates. That is because the magnitude of stocks declines seasonally and sharply from December 1 to September 1 so that a surprise of equal bushel size in December and September has very different market implications. In addition, comparing market surprises for corn and soybeans in absolute terms is not meaningful since corn stocks

[13] If the set of market analysts surveyed is drawn randomly then the average of the surveyed analysts should be an unbiased measure of overall industry expectations. The set of market analysts surveyed each quarter does change over time as individuals change jobs or retire, new firms are started, existing firms are sold or merged with other firms, or firm policies change about contributing to the survey. If these changes are random over time then the average of the surveyed analysts should continue to be an unbiased measure of overall industry expectations. We did not have access to the individual analyst expectations each quarter, as our data only included the average across the individual analysts. So, we are not able to provide information on the changing nature of the set of market analysts surveyed each quarter. Finally, even if the average of the surveyed market analysts is unbiased there may be issues of measurement error "noise" that could affect the precision with which average industry expectations are measured (Rigobon and Sachs, 2006).

are much larger than soybean stocks. An alternative is to view the analyst errors in percentage terms. This makes comparisons across quarters and across commodities more meaningful. The *Percent Surprise*$_{m,t}$ for the stock estimate made in quarter *m* of marketing year *t* is calculated as follows:

(11) $\textit{Percent Surprise}_{m,t} = 100 \times (\textit{NASS Estimate}_{m,t} - \textit{Analyst}_{m,t})/\textit{NASS Estimate}_{m,t}$

where all variables are defined as before. Descriptive statistics for percent surprises are calculated for each quarter over the study period and presented in Tables 25 and 26 for corn and soybeans, respectively. The average of percent surprises in Table 25 shows that analysts tend to over-estimate corn stocks in December and under-estimate stocks in March, June and September. The average surprise, however, is not statistically different from zero for any quarter. The average of absolute percent surprises for corn increases through the marketing year, approaching six percent in September. The NASS corn stock estimates fell within the range of analyst estimates 48 percent of the time in December, 70 percent of the time in March, 78 percent of the time in June, and 48 percent of the time in September. The average of percent surprises in Table 26 indicates that analysts tend to over-estimate soybean stocks in December and March and under-estimate stocks in June and September. The average surprise is statistically different from zero in September. The average of absolute surprises for soybeans also increases through the marketing year, nearing 10 percent in September. NASS soybean stocks estimate fell within the range of analyst estimates about 60 percent of the time in December and March, 70 percent of the time in June, and only 43 percent of the time in September. In sum, the descriptive statistics in Tables 25 and 26 suggest that the September stocks estimate is most difficult for market analysts to anticipate and that soybean stock estimates are somewhat harder to anticipate than corn estimates.

The percent surprise for NASS corn and soybeans stocks estimates is also presented graphically in order to provide a more detailed perspective. Figures 33-36 show corn surprises for the same quarter across time and Figures 37-40 show the same for soybeans. Figures 41 and 42 present the surprises in chronological order every quarter over the sample period for corn and soybeans, respectively. The figures reveal that while the average percent surprise was significantly different from zero only for soybeans in September, large surprises also occasionally occurred in both corn and soybeans in some quarters. For corn, the surprise exceeded three percent only one time in December and two times in March, exceeded five percent three times in June, and exceeded 10 percent five times in September (all in the most recent seven years). There was an increase in the overall magnitude of surprises for corn beginning with the 2007 crop (most evident in Figure 41). For soybeans, the surprise exceeded four percent twice in December and five times in March, exceeded six percent two times in June, and exceeded 15 percent four times in September. The frequency of large surprises for soybeans also appears to have increased beginning with the 2007 crop (most evident in Figure 42), but the timing is different than for corn. In additional, all of the large surprises for soybeans were in September.

Viewing market surprises in percentage terms provides some useful insight into the frequency and timing of large surprises and may be more useful than evaluating surprises in quantity terms. Still, calculating surprises in percentage terms does not provide a completely satisfactory method of normalizing surprises within a context of declining stock levels through the marketing year. That is, in calculating the percent surprise, the divisor gets smaller through the marketing year and even relatively small bushel surprises can create large percentage surprises for September 1 stocks (especially in years with minimal carryout stocks). Additionally, to the best of our knowledge, market analysts do not actually directly estimate stock levels each quarter. Instead, analysts start with the NASS stock estimate for the previous quarter, estimate usage for the current quarter, and then estimate stocks for the current quarter by subtracting estimated usage for the quarter from the sum of the NASS stock estimate for the previous quarter and imports during the current quarter. So the focus of the analysis is on usage for the current quarter, not ending stocks for the quarter. More formally, this approach starts with the following relationship:

$$(12) \quad E_t(Stocks_t) = Stocks_{t-1} + E_t(Production_t) - E_t(Domestic_t) + E_t(Imports_t) - E_t(Exports_t).$$

That is, the expectation of stocks for the end of quarter *t* equals the known stocks level at the end of quarter *t-1* plus expected production during quarter *t* less expected domestic usage during the quarter plus expected net trade. The *t* subscript on the expectations operator indicates the expectation is taken at the end of quarter *t*. The use of the expectations operator for current quarter observations reflects reporting lags.

For corn, monthly Census Bureau trade statistics coupled with weekly *Export Inspections* data provide for fairly accurate assessments of trade during the quarter. Domestic usage of corn consists of food use, seed use, industrial use, and feed or residual use. Quarterly seed use is small and relatively consistent from year-to-year so it can be very accurately estimated for the current quarter. Ethanol use of corn can be directly estimated from weekly and monthly estimates of ethanol production provided by the U.S. Energy Information Administration. Other food and industrial uses of corn are also very stable from year-to-year and quarter-to-quarter and can be fairly accurately estimated. The estimate of feed and residual use contains the most uncertainty as there is no official measure or method to track corn disappearance into animal feeds. Analysts rely on the historical pattern of quarterly feed and residual use and changes in livestock numbers and availability of other grains for feeding in order to form estimates of use during the quarter. The historical pattern includes the well-known tendency of feed and residual use in corn to vary more with the size of the corn crop than is expected based purely on price changes. This leads to a positive correlation between feed and residual use and crop size that is "large" (e.g., Hudson, 2011). We assume that market analysts are aware of this historical tendency and incorporate it into their expectations of usage and stocks.

For soybeans, the trade also has good data on imports and exports. Soybeans processed domestically have traditionally been known from the monthly Census Bureau report on *Oilseed Crushings*. However, that report was terminated after July 2011. Since that time, analysts have relied on the crush estimates supplied by the National Oilseed Processors Association (NOPA). Unlike corn, soybeans do not have a direct and material use as animal feed. The difference between total use during the quarter and known exports and domestic use is allocated to a feed, seed, and residual category. Use in that category is small and follows a seasonal pattern that allows analysts to anticipate use in that category. As a result, use of soybeans during a quarter is known with more accuracy than the use of corn.

When viewed in this manner, it is clear that analysts' estimates of corn and soybean stocks are really estimates of usage or implied usage during the quarter that ends with the reference date of the NASS *Grain Stocks* report. This can be seen by first defining total usage in equation (12) as:

$$E_t(Usage_t) = E_t(Domestic) + E_t(Exports_t) - E_t(Imports_t), \quad (13)$$

Then, substituting (13) into (12), we can write:

$$E_t(Stocks_t) = Stocks_{t-1} + E_t(Production_t) - E_t(Usage_t). \quad (14)$$

This shows that given stocks for the previous quarter and estimates for production and total usage one can derive an estimate for ending stocks for the current quarter. Finally, we can use equation (14) to convert the ending stocks estimates reported by market analysts back to total implied usage as follows:

$$E_t(Usage_t) = Stocks_{t-1} + E_t(Production_t) - E_t(Stocks_t). \quad (15)$$

We use the term "implied usage" to describe the results of the conversion. For example, the average analyst estimate for the March 1 corn stocks in the 2011-2012 marketing year was 6,151 million bushels. The actual stocks on December 1 were 9,642 million bushels. Production during the December-February quarter was zero so the usage level implied in the average analyst estimate is 3,491 million bushels (9,642 – 6,151) for the quarter. The actual March 1 grain stocks were reported by NASS at 6,009 million bushels for an actual usage of 3,633 (9,642 – 6,009). In this example, the percent surprise for the average market analyst implied usage is 3.9 percent [(3,633-3,491)/3,633]. This compares to the -2.4 percent surprise that is computed using the NASS and average analyst stocks estimates [(6,009-6,151)/6,009]. The sign reversal between the two measures is expected, as bigger stocks implies less implied usage and *vice versa*.

One remaining issue is that for the first quarter (September-November) implied usage, the expected production for corn and soybeans is not zero. To correctly make this adjustment, the average market analyst estimate of production in January is used as the expected production. For example, the implied estimate of usage in the first quarter of the 2011-2012 marketing year (4,007) equals the average market analyst estimate for production (12,280) plus the actual September 1 stocks (1,128) minus the average market analyst estimate for December 1 stocks (9,401). The implied market analyst estimate for corn usage can then be compared to the actual usage (3,844) which equals the actual final production (12,358) plus the actual September 1 stocks (1,128) less the actual December 1 stocks (9,642). In this case, then the market surprise is computed as -4.2 percent [(3,844-4,007)/3,844]. Importantly, the surprise in the analyst's estimates of first quarter usage necessarily comingles uncertainty regarding actual production. For comparison purposes, the surprise in the analyst stocks estimate was 2.5 percent [(9,642-9,401)/9,642].

Using this approach to examining corn and soybean stocks estimates—through implied usage estimates—makes it clear that surprises in anticipating stocks largely reflect analyst surprises in estimating usage. For corn, this is primarily manifest in the estimation of feed and residual usage. From a statistical perspective, surprises measured relative to implied usage are true "apple-to-apples" comparisons, as there are no distortions due to changing stock levels seasonally and across commodities.

We use equation (15) to compute analysts' estimates for implied usage for each quarter in the September-August marketing year and compare to the actual usage implied in the NASS corn and soybeans stocks estimates. The bushel surprise for implied usage is computed as:

(16) $\textit{Bushel Surprise}_{m,t} = \textit{Actual Implied}_{m,t} - \textit{Analyst Implied}_{m,t},$

where $\textit{Actual Implied}_{m,t}$ is the implied usage for quarter *m* in marketing year *t* based on NASS stocks estimates and $\textit{Analyst Implied}_{m,t}$ is the implied usage for quarter *m* in marketing year *t* based on the average market analyst stocks estimates. The calculated bushel surprises are shown in Tables 27 and 28. Once again, surprises were in both directions and in a wide range during the study period, with the largest surprises generally for corn. There was also a tendency towards substantially larger surprises in corn usage starting in 2006. Most notably, the surprise was at least 300 million bushels (in absolute value) in five instances over 2009-2012, which dwarfs the size of any surprises pre-2007.

Computing implied usage surprises in percentage form is likely more relevant than computing surprises in bushel form because usage is not equal across marketing years, through the marketing year, or across corn and soybeans. The percent surprise for implied usage is calculated for each quarter *m* in each marketing year *t* as follows:

(17) $Percent\ Surprise_{m,t} = 100 \times (Actual\ Implied_{m,t} - Analyst\ Implied_{m,t}) / Actual\ Implied_{m,t},$

where the variables are as defined previously. Table 29 presents the average percent surprise and tests for bias in the analysts' implied corn usage estimates. The only statistically significant (5 percent level) bias is found in the 1990-2000 sub-sample for the first quarter (Sept.-Nov.) where implied usage estimates are too low, or under-estimated. The first quarter underestimation is not present in the later sub-sample. While there appears to be some tendency for analysts to over-estimate usage in the second sub-sample for the second and third quarters, and particularly for quarter four, none of the estimated biases are statistically significant.

The average absolute percent surprises for corn are presented in Table 30. For the entire sample (1990-2012) the average absolute percent surprise is fairly consistent across quarters, ranging from 3.02% in the first to 3.45% in the fourth. In the first sub-sample (1990-2000) the smallest percent surprises are in the second quarter and in the second sub-sample (2001-2012) the smallest are in the second quarter. Across the two sub-samples, absolute percent surprises are about the same in the first quarter but are noticeably smaller in the first sub-sample in the last three quarters. The *t*-tests for a difference in means across the two samples fail to reject the null of equal absolute surprises for any of the quarters. As before, changes through time are also tested by regressing the absolute percentage surprise in the analyst implied usage estimates against a linear time trend.

(18) $$|Percent\ Surprise_{m,t}| = \alpha + \beta Trend_t + e_t$$

where $Trend_t$ is a time trend variable for marketing year *t* that takes a value of 1 in 1990-91, 2 in 1991-92, and so on and e_t is a standard, normal error term. The coefficient on the time trend and the corresponding t-test that the coefficient is zero are reported in bottom row of Table 30 for corn. Across all quarters, the estimated trend coefficient is positive. For the second and fourth quarters, the estimated coefficient is statistically different from zero at the 5 percent level. For example, in the December-February quarter market surprises have increased at an average of 0.19 percent per year. Absolute surprises in the fourth quarter have increased by a statistically significant 0.24 percent per year from 1990 through 2012. Collectively, these results suggest that analyst estimates of implied usage and subsequent corn stocks levels are not biased. However, there has been a marked statistical decline in analysts' ability to anticipate actual corn usage as implied by NASS corn and soybean stocks estimates.

The percent surprises for NASS corn implied usage estimates are also presented graphically in order to provide further perspective on recent patterns. Figures 43-46 show corn surprises for the same quarter across the sample period. The figures reveal that the vast majority of implied usage surprises were in a range of approximately plus/minus five percent previous to 2006. This range can then be used as a screen to help identify NASS estimates for corn that were the biggest surprises to market analysts. Table 31 highlights in yellow all of the market surprises over 1990-2012 that exceeded plus/minus five percent. Over 1990-2005, there were 7 instances out of 64 where the surprise exceeded the threshold, or about 11 percent of the time. In contrast, over 2006-2012, there were 12 instances out of 28 where the surprise exceeded the threshold, or 43 percent of the time. Furthermore, double-digit surprises occurred three times during 2006-2012 (-11.55 percent: June-August 2009; -12.13 percent: March-May 2010; -14.66 percent: December-February 2012), and each substantially exceeded the largest surprise observed over 1990-2005 (+7.78 percent: March-May 1995). It is also interesting to note that 5 of the 12 instances that exceeded the threshold over 2006-2012 were associated with December-February and March-May implied usage estimates. Usage estimates should be less problematic during these quarters because issues associated with old crop/new crop accounting should not be present (see discussion in the next section).

Figure 47 presents all of the surprises for NASS implied usage estimates in chronological order and it highlights the sharp increase in the volatility of market surprises for implied corn usage that has occurred since 2006. More specifically, the standard deviation of market surprises in 2006-2012, 6.2 percent, is twice the standard deviation over 1990-2005, 3.1 percent. Figure 47 also highlights three relevant tendencies regarding the "large" surprises since the start of the 2006 marketing year: i) the number of over-estimates (7 negative values) is roughly equal to the number of under-estimates (5 positive values), ii) over-estimates (-9.3 percent average) are somewhat larger in magnitude than under-estimates (+7.3 percent), and iii) there is some tendency towards reversals of the over- and under-estimates through time. This last tendency is illustrated more directly in Figure 48, which shows that the quarter-to-quarter correlation over 2006-2012 for all implied usage surprises in corn was -0.29.[14] While this correlation is not statistically significant, the tendency towards reversals for large surprises (larger than plus/minus five percent in absolute value) is evident.

[14] The correlation of quarter-to-quarter surprises over 1990-2005 was -0.12 and not statistically significant.

Further insight into the patterns of market surprises in NASS implied usage estimates for corn is provided by Figure 49, which shows the surprises by marketing year for each year between 2007 and 2012. It is readily apparent from this figure that the most problematic surprises occurred in the 2009, 2010, and 2012 marketing years. Surprises for the other three marketing years were generally within the normal range of plus/minus five percent. Within the three problematic years of 2009, 2010, and 2012, there is also a clear tendency towards reversal of the surprises from quarter-to-quarter. The pattern was especially strong in 2009 and 2012 when the surprises swung back and forth from positive to negative each quarter. Reversals in these three marketing years are the primary drivers of the overall negative correlation in surprises for 2006-2012 shown in Figure 48. While the pattern in the surprises quarter-by-quarter during 2009, 2010, and 2012 is not uniform, there are some potentially interesting tendencies. All of the surprises for these three marketing years are positive for the first quarter, two of three are negative for the second quarter, two of three are positive for the fourth quarter, and all three are negative for the further quarter.

Analysts' estimates for implied soybean usage are compared to actual usage as implied by the NASS stocks estimates in similar fashion as those shown for corn. The bias in market surprises for soybeans is presented in Table 32 and the tests for changes through time are shown in Table 33. The results in Table 32 show that analysts tended to under-estimate soybean usage in the first and second quarters from 1990-2000 and over-estimate usage in the final quarter of the marketing year. However, these biases largely disappear in the second sub-sample from 2001-2012, except in the fourth quarter. As a result, the only marginally significant (10 percent level) bias across the entire sample is the 2.35 percent over-estimation of usage in the final quarter of the year. Table 33 provides no conclusive evidence that analysts' estimates of implied soybean usage have gotten either better or worse in recent years. It is noteworthy, that the average absolute surprise is larger (4.84 percent) in the final quarter of the year than the third quarter (2.9 percent) which has the smallest surprise. The tendency for the fourth quarter to have the largest surprise (and the third quarter to have the smallest) is true across both sub-samples and may be driven by the bias reported in Table 32. The difference in means test shows no statistically significant shift in accuracy across the two time periods. Likewise, the estimated coefficient on the time trend variable is not of uniform sign across quarters and none of the estimated coefficients are statistically different from zero.

The lack of trends in implied soybean usage surprises is also evident in Figures 50-53, which show the surprises by quarter. In addition, the contrast in the pattern of implied usage surprises for corn across all quarters in Figure 47 with that of soybeans in Figure 54 is striking. After normalizing by implied usage, there is little evidence that recent surprises in soybeans have been outside of historical ranges, whereas the evidence is overwhelming that surprises have been outside the historical range in corn.[15] More specifically, the standard deviation of market surprises in 2006-2012, 4.7 percent, is almost exactly the same as the standard deviation over 1990-2005, 4.8 percent. Furthermore, as illustrated in Table 34, the three largest implied usage surprises for soybeans during 1990-2012 occurred between 1990 and 1995. Figures 55 and 56 also suggest there is some evidence of a tendency towards reversals in surprises from quarter-to-quarter in soybeans, although not as strongly as in corn. Overall, there is no compelling evidence that analysts' implied estimates of quarterly soybean usage have gotten any more or less accurate since 1990.

The most important finding of the analysis in this section is the sharp decline in analysts' ability to anticipate actual quarterly corn usage as implied by NASS *Grain Stocks* reports since the start of the 2006 marketing year. Since non-feed and residual usage of corn can be anticipated fairly closely, the difficulty appears to be in anticipating feed and residual usage of corn during the quarter. One way of illustrating this difficulty is to show the changing and inconsistent pattern of quarterly feed and residual usage for corn implied by the NASS stocks estimates. After each quarterly NASS *Grain Stocks* report, the Economic Research Service of the USDA publishes quarterly feed and residual usage estimates.[16] These are computed using a similar methodology to that outlined above for implying the quarterly total usage estimates of market analysts. The main difference is that total usage for the quarter is assumed to be known and given by the difference between the current NASS stocks estimate and the one for the previous quarter (plus imports). Then, "known" domestic and export usage is subtracted from the total to arrive at a feed and residual estimate. Figures 57 through 60 show the estimated quarterly feed and residual usage of corn as a percent of total usage for the year over the 1990-2012 marketing years. The figures reveal that, in general, a larger percentage of usage has occurred in the first quarter (September-November) and a smaller percentage in the fourth quarter (June–August). As a result, there is a clear pattern of a larger (smaller) percentage of the usage in the first (last) half of the marketing year beginning with the 2007 marketing year, as shown in Figures 61 and 62.

Part of that shift to more apparent feed and residual usage in the first of half of the marketing year may reflect the increase in corn production in Southern states that

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[15] The importance of normalizing by implied usage is easily seen by comparing Figures 42 and 52. When soybean stock surprises are expressed as a percent of quarterly stock levels (Figure 42) there appears to be substantially more volatility in surprises after 2006. However, when surprises are normalized by implied usage (Figure 52) the apparent increase in volatility for soybeans disappears.

[16] The estimates are published in monthly *Feed Outlook* publications found at the following webpage: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1273.

occurred beginning in 2007, where more harvest is completed before September 1.[17] The percentage of the corn crop produced in non-traditional corn states in the South (Alabama, Arkansas, Georgia, Mississippi, and South Carolina) averaged 1.4 percent from 2004 through 2006, ranged from 2.0 to 2.7 percent from 2007 through 2011, and was 3.5 percent in 2012. However, that shift does not seem to explain the continued decline in fourth quarter feed and residual use as a percentage of the marketing year total. The early harvest in 2010 and especially in 2012 in the Midwest may explain some of the observed shift, but the sharp decline in fourth quarter feed and residual use observed in the 2012 marketing year is not likely explained by more than average harvesting of new crop corn before September 1, 2013. A partial explanation for the small amount of feed and residual use of corn during the fourth quarters of the 2011 and 2012 marketing years may lie in the relatively large feed and residual use of wheat during those quarters, as illustrated in Figure 63. The combined total of feed and residual use of wheat and corn during the fourth quarter of the corn marketing year is shown in Figure 64. The combined total has been relatively constant since 2009. While the variation in the magnitude of fourth quarter wheat feed and residual usage may explain some of the variation in fourth quarter corn feed and residual usage of corn, a structural change in combined usage is still observed beginning in 2006. In addition, the correlation between the magnitude of fourth quarter wheat feed and residual usage and the magnitude of the market surprise in the September 1 NASS corn stocks estimate is relatively low (0.25) and not statistically significant.

The structural shift in the quarterly pattern of feed and residual use is further illustrated in Figure 65. That figure depicts the percentage of feed and residual use of all grains that occurred in the first (September-November) and last (June-August) quarters of the corn marketing year from the 1992 through 2012 marketing years. The pattern towards a larger (smaller) percentage of use in the first (fourth) quarters since 2005 is clear. Since the feeding of distillers' grains has increased substantially, part of the quarterly shift in feed and residual use of grains could be explained by a distinctive seasonal pattern in production and feeding of distillers' grains. However, as shown in Figures 66 through 69, there is little seasonal variation in ethanol production, implied production of distillers' grains (based on ethanol production), apparent domestic usage of distillers' grains, or exports of distillers grains. While increased feeding of distillers' grains may explain part of the overall decline in feed and residual use of corn since 2005, it does not contribute to the explanation of the shift in the seasonal pattern of feed and residual use. In sum, the structural change in quarterly feed and residual usage likely makes it more difficult for analysts to anticipate feed and residual usage, particularly in the first

[17] See Westcott and Norton (2012) for a detailed discussion of early corn harvesting and feed and residual use estimates.

and fourth quarters, but large errors have also been observed for the second and third quarters.

Figures 57 through 60 also reveal relatively wide swings in implied quarterly feed and residual usage beginning in the 2006 marketing year. The magnitude of the variation by marketing year and quarter is summarized in Figure 70 for the 2007 through 2012 marketing years. The large variation, even in the second and third quarters of the marketing year, means that analysts did not anticipate usage numbers well in numerous instances and were justifiably surprised by the stocks estimates on several occasions. Not surprisingly, the discrepancies from historical feed and residual usage patterns were concentrated in the 2009, 2010, and 2012 marketing years, the same years where total usage surprises were most problematic. While the large variation in these marketing years certainly surprised market analysts, close inspection of Figure 70 reveals once again the tendency towards reversals noted earlier in this section. Whenever large deviations from historical feed and residual patterns occurred during 2009-2012, they were generally reversed in subsequent quarters. This implies that total annual feed and residual usage for these marketing years may not have been estimated with more than the normal error. The problem from the perspective of market analysts was the accuracy of the implied usage estimates within the marketing years.

The inconsistent pattern of quarterly feed and residual use of corn at times beginning in the 2006 marketing year, as implied by NASS quarterly stocks estimates, undoubtedly led to large surprises about the pace of usage within marketing years. The corn market reflected those surprises with large price changes following the release of some NASS stocks estimates. Figure 71 plots the reaction of daily nearby corn futures prices to the release of the NASS *Grain Stocks* report over 1990-2012 and it reveals that not only were the price changes large on occasion, but also that price volatility following release of the reports was in general substantially higher starting with the 2006 marketing year.[18] The standard deviation of the daily market price reaction in 2006-2012, 4.0 percent, was over two times the standard deviation over 1990-2005, 1.7 percent. Not surprisingly, as shown in Figure 72, there is a strong relationship between the price changes following release of the reports in corn and the magnitude of surprises in NASS implied usage estimates. Figures 73 and 74 show that the volatility of soybean

[18] Before calendar year 2013, the percent change in nearby corn futures is based on difference in settlement prices the day the NASS *Grain Stocks* report is released and the day after the report is released. Starting in calendar year 2013, the release time of the *Grain Stocks* report was changed to noon EST during the Chicago Mercantile Exchange daytime trading hours for corn futures. Consequently, starting with the January 2013 release of the *Grain Stocks* report, the percent change in nearby corn futures is based on difference in settlement prices the day before the NASS *Grain Stocks* report is released and the day the report is released. Note also that if the settlement price after release of the report is locked at the daily allowable price limit, nearby settlement prices for the next day are used.

futures prices was largely the same in 2006-2012 compared to 1990-2005 and that there is little relation between soybean price changes and the magnitude of NASS implied usage estimates for soybeans.[19]

In sum, the analysis in this section provides important background information for understanding some of the criticism of the NASS stock estimates and estimating procedures that has been offered in recent years. One pattern is abundantly clear—there has been a sharp decline in analysts' ability to anticipate actual quarterly corn usage as implied by NASS *Grain Stocks* reports since the start of the 2006 marketing year. This has undoubtedly decreased confidence in the integrity of the underlying stock estimation procedures among at least some market participants. Since this pattern coincides with the era of tight supply and demand conditions and elevated grain prices that began in the autumn of 2006, there has been much discussion about how the two may be possibly related. While it is not surprising that market participants are highly sensitive to data on stocks when supply and demand conditions are tight, the mechanism that ties together these conditions and the decline in analysts' ability to anticipate NASS stocks estimates is far from obvious. The following section examines the explanations that have been offered for why NASS methodology may have resulted in errors in estimating corn stocks since the 2006 marketing year.

Explanations for Surprises in NASS Corn Stocks Estimates

A number of potential explanations for the increase in the number and magnitude of surprises in NASS quarterly corn stocks estimates since the 2006-07 marketing year have been offered by various market participants. These explanations include:

1) Issues associated with NASS grain stocks estimates:

    a) Reporting biases by producer respondents associated with a combination of estimating stocks based on volume rather than weight and larger grain bins that create estimation and/or measurement errors.

[19] The lack of price reaction in soybeans to NASS implied usage surprises seems odd at first glance. However, implied usage surprises in soybeans are largely related to surprises in the seed, feed, and residual category, which is a relatively small component of total soybean usage. This is not the case in corn where the implied usage surprise contains information on the much larger feed and residual category. Soybean futures prices after release of NASS stock estimates have a small positive correlation with the implied usage surprise for corn (0.13).

b) Mixing of old crop and new crop stocks by respondents to the September Agricultural Survey and those completing the Grain Stocks Report

c) Failure to capture the changing geography of corn production over time

d) Failure to capture the change in number and size of on-farm storage facilities.

e) Changing make-up of the survey sample for the Agricultural Surveys during the marketing year.

f) Reduced response rate to the Agricultural Surveys.

g) Increased errors in grain stocks reporting by commercial facilities associated with the large increase in the number of ethanol plants.

h) An increase of corn in transit on the reference date for the stocks estimates due to the increased movement of grain off-farm to ethanol plants.

2) Incorrect WAOB estimates of corn used for ethanol production

3) Unresolved errors in NASS corn production estimates.

Importantly, the analysis in the previous section indicates that to have credibility the explanations need to satisfy at least four criteria:

1) Why corn and not soybeans? The number and magnitude of surprises in the corn stocks estimates/implied usage must be explained in light of the absence of similarly large surprises in soybean stocks estimates.

2) Why 2006-2012 and not earlier? A notable increase in the volatility of market surprises in corn stocks estimates/implied usage was observed starting with the 2006 market year and the increase compared to earlier periods must be explained.

3) Why only in particular marketing years? The size and magnitude of surprises in corn stocks estimates/implied usage show large variation from year-to-year during 2006-2012 and tended to be concentrated in the 2009, 2010, and 2012

marketing years. The occurrence in certain years and not others must be explained.

4) Why a pattern of reversals during marketing years? The pattern of surprises in stocks estimates/implied usage within the marketing year during 2006-2012 must be explained, and in particular, the tendency toward reversals within the 2009, 2010, and 2012 marketing years.

Using these criteria, all but one of the explanations presented above can be dismissed out of hand. Still, it is useful to examine each of the proposed explanations in some detail and identify where they fall short. The following sections provide a discussion of the identified explanations.

Issues Associated with NASS Grain Stocks Estimates

Reporting Biases of Survey Respondents

It is argued by some that respondents to the Agricultural Surveys provide corn stocks estimates based on volume of inventory rather than weight of inventory. That is, estimates are based on the rated capacity of storage facilities and the percent of capacity represented by the current volume of grain in the facility. Such estimates that reflect volume of grain in storage may not account for variation in density (test weight) of corn from year-to-year. Since stocks are measured in terms of 56-pound bushels, not accounting for variation in density could result in reporting errors. The logic of the argument is correct and might explain errors in individual reporting of stocks for corn and not soybeans and also explain why errors occur in some years and not others. However, the argument falls short based on other criteria. In particular, such reporting errors would not explain why some quarterly stocks estimates within the marketing year are near analyst expectations and others are not. That is, the argument would not explain why respondents correctly account for density in some quarters but not others. In addition, to explain the large magnitude of errors in some quarters would require that respondents estimates are biased, that is respondents generally make estimation errors in the same direction, and given the tendency towards reversals in surprises, respondents need to make systematic estimation errors but in the opposite direction.

The 2009 corn crop provides a useful case study of the volume versus weight explanation for usage surprises. The crop was widely acknowledged to be characterized by low test weights (e.g., Hurburgh and Elmore, 2009), which could lead to over-estimates of stock levels and under-estimates of usage if producers reported inventories to NASS by volume instead of by weight.[20] Table 33 shows that the December 1, 2009 NASS stock estimate for corn instead resulted in a +2.3 percent positive surprise, implying that market analysts under-estimated usage compared to that implied by the NASS stock estimate by +2.3 percent. If producer stock estimates were biased upwards, it would be odd for market analysts to be surprised in the opposite direction. However, since some of the surprise for December 1 inventories may be explained by subsequent January NASS revisions in corn production (see the discussion in a following section), this observation may not be the best indicator of possible reporting biases by producers. The surprise in implied usage in the next NASS stock estimate for corn on March 1, 2010 was -5.7 percent, which implies that market analysts substantially over-estimated usage for the previous quarter. This could be explained by an upward producer volume bias. But, the following NASS stock estimate for June 1, 2010 implied a very large implied usage surprise in just the opposite direction, +8.96 percent. By the logic of the producer volume bias, such a large under-estimate of usage would imply that producers moved from over-estimating stocks in the second quarter to under-estimating stocks in the third quarter. The last NASS stock estimate in corn for the 2009 marketing year on September 1, 2010 resulted in another reversal, with a historically very large -11.55 implied usage surprise.

This discussion illustrates the difficulty of explaining market surprises for NASS implied usage estimates even in years when the corn crop is characterized by low test weights and producers might plausibly over-estimate stocks. The pattern of reversals makes it highly unlikely that this explanation is valid. Some have argued that producers initially over-estimate corn stocks in low test weight years and then later in the marketing year discover their mistake once some grain bins are emptied. Having discovered their mistake, they compensate in later NASS surveys by under-estimating corn stocks. This systematic pattern of over- estimating stocks around harvest due to low test weight and then compensating by under-estimating stocks later in the marketing year once the mistake is discovered on the part of tens of thousands of producers stretches credibility beyond the breaking point. There is also the more general question of the impact of test weight and other quality issues on corn usage. There is the possibility that lower test weight crops result in greater processing uses of corn (see Nielsen, 2012), which could work in the opposite direction of a producer volume bias.

A related density argument is that larger grain bins that are thought to have become more common in recent years result in compaction of grain that results in errors in measuring or estimating the number of 56-pound bushels in the bin. This argument might satisfy the "Why Corn" criteria, but falls short in explaining the year-to-year and quarter-to-quarter errors in analyst expectation of corn stocks. The argument implies

[20] This assumes that commercial off-farm inventories are not subject to the same possible bias since these inventories are weighed upon delivery.

that compaction sometimes results in estimation errors, but not always. In addition, widespread failure to recognize compaction issues by respondents should result in consistent under-reporting of stocks. In fact, market analyst errors have been in both directions.

The issues associated with the estimation of on-farm corn stocks were informally discussed with about 10 corn producers in East-Central Illinois in the summer of 2013. The discussion revealed that producers were very much aware of the impact of test weight and compaction on stocks estimates and accounted for these factors when making estimates of on-farm stocks. There was also general agreement that widespread use of yield monitors, which are calibrated for test weight, substantially reduce errors in estimating on-farm stocks. In addition, some even have “compaction tables” that help quantify the effect of compaction on storage capacity. Finally, it is not uncommon for producers to use grain cart scales to determine the quantity of corn placed in a storage facility.

While errors in reporting stocks by individual respondents can be expected, there simply is no convincing evidence that the error rate should have increased since 2006. More importantly, there is no evidence to suggest a pattern of bias in estimating or reporting the magnitude of quarterly on-farm stocks of corn since 2006 that would explain implied usage surprises. If anything, investments in improved on-farm grain handling technology and farm consolidation should have increased the accuracy of on-farm respondents.

Mixing of Old Crop and New Crop Stocks for September 1

Analyst errors in anticipating September 1 stocks estimates of corn are often explained by claims that NASS stocks estimates include some stocks of the new crop harvested before September 1. This explanation is likely incorrect for a number of reasons. First, inclusion of new crop stocks in the estimates should result in analysts consistently anticipating stocks below the NASS estimate. That clearly has not been the case. Second, the NASS Agricultural Survey form specifically asks respondents to report only stocks of “old crop” grain. For the September 2013 Survey, for example, respondents were asked to report stocks of corn and soybeans from 2012 and earlier crop years. Informal conversations with producers reveal that they have little or no difficulty in separating old crop and new crop inventories. Third, the Grain Stocks Report form for commercial storage facilities historically asked respondents to report only old crop inventories and more recently asks respondents to estimate old and new crop inventories separately. An informal conversation with managers of three grain companies in East-Central Illinois revealed that there is some degree of judgment in distinguishing between old and new crop stocks on September 1. Grain firms keep daily in/out records so they know total inventories on September 1. However, those records do not distinguish between old and new crop. Based on harvest progress and knowledge about deliveries and shipments, managers make informed estimates of old and new crop inventories. Some error in distinguishing between the two should be expected, but a bias in those estimates would not be expected as some may over-estimate and some may under-estimate old crop stocks.

Changing Geography of Corn Production

Some question if NASS survey procedures have kept up with the expansion of corn production outside of the traditional large corn producing states since 2006. This argument lacks validity on the surface. NASS does not have Agricultural Surveys for individual crops. Instead, surveys are conducted for a sample of all crop producers who are asked to account for all crop acreage and for stocks of all crops. Producers in the states where corn acreage, and presumably corn storage capacity, have increased would be appropriately represented in the sampling process for the surveys. Similarly, commercial facilities are asked to account for stocks of all crops so that corn inventories in states where corn production has expanded are reported in the quarterly *Grain Stocks* surveys completed by these firms.

Figure 75 shows the percentage of corn production occurring outside the seven states in the central Corn Belt from 1990 through 2012 and the percentage of March 1 corn stocks in those states. The increase in corn stocks held in those states on March 1 has been proportional to the increase in production from 2007 through 2012. Figure 76 shows the percentage of stocks held outside the 7-state area for each of the four quarters. The proportion of stocks held outside the 7-states has steadily increased in each quarter since 2007, with the exception of the leveling of the proportion in September since 2008. As shown in Figure 77, there was also a geographical shift in soybean production beginning in 2003, with a larger percentage of production occurring outside the seven central Corn Belt states. The percentage of stocks held outside those states on March 1 made a one-time increase in 2008, but the increase was proportionately smaller than the shift in production. This is in contrast with the proportional shift seen in March 1 corn stocks. This is mirrored in Figure 78, which shows the percentages of soybean stocks outside of the 7-states for each quarter.

The relationship between geographical changes in corn and soybean production and the location of stocks is stronger for corn than soybeans. At the same time, there has been little if any criticism of the NASS sampling procedure for estimating soybean stocks. The argument that NASS methodology has not kept pace with regional shifts in corn production fails to satisfy the four criteria for explaining surprises in NASS quarterly stocks estimates

Changing Number and Size of On-Farm Grain Facilities

Some argue that the Agricultural Survey has not adequately captured the impact of the increased number and size of on-farm storage facilities. Figure 79 shows that U.S. grain storage capacity has grown in recent years. Total storage capacity rose from 20.4 billion bushels in 2006 to 23.2 billion bushels in 2012, or an increase of 2.8 billion bushels (13.7 percent). On- and off-farm capacity increased by similar amounts, 1.3 and 1.5 billion bushels, respectively. As shown in Figure 80, this resulted in a small increase in the share of the total capacity represented by off-farm storage relative to on-farm storage. Even though on-farm storage capacity has grown in absolute terms, the argument that this has resulted in less accurate responses from on-farm survey respondents is lacking for several reasons. First, on the surface since it implies that producers have more difficulty estimating corn inventories if they have more and/or larger storage facilities than in the past. This ignores the fact that grain handling and measuring technology (e.g., combine yield monitors, grain cart weight scales, etc.) have been improving at the same time. The argument also implies that producers have more difficulty estimating corn inventories than soybean inventories and they have more difficulty in some quarters than in other quarters. Finally, the argument implies that producers uniformly over- or under-estimate inventories in a particular quarter, but not in every quarter and that the direction of the bias changes from quarter-to-quarter.

Changing Make-Up of Survey Sample During the Marketing Year

A recent criticism of NASS methodology for conducting the Agricultural Survey is that the group of respondents to the Survey is not consistent from quarter-to-quarter. There are two issues cited as part of this particular criticism. One is that the number of producers surveyed is not consistent throughout the annual survey cycle that begins in June. The sample size in a recent survey cycle, for example, was 96,022 in June, 65,953 in September, 82,760 in December, and 83,089 in March. The number of producers who responded to all four Agricultural Surveys in the cycle was 32,328. The number responding to the grain stocks section of the Agricultural Survey in the 2012-13 cycle (rounded to the nearest 100) was 68,900 in June, 53,400 in September, 65,800 in December, and 64,900 in March. Critics argue that the changing number and make-up of survey respondents through the survey cycle could account for inconsistent stocks estimates from quarter-to-quarter. The second issue is associated with the timing of the sample selection for the Agricultural Surveys. The sample for the annual cycle is selected for the June Survey and is maintained through the cycle. A new sample is drawn the following June. Since the marketing year for corn and soybeans runs from September through August, the survey respondents for the June and September Surveys are drawn from a different sample than respondents for the December and March surveys. The difference in the samples during the survey cycle is thought to create the potential for inconsistent stocks estimates.

The criticism based on changing survey respondents appears to be without merit for two reasons. First, since the methodology has not changed over time, it would not likely explain the more frequent incidences of surprises in the NASS corn stocks estimates since 2006. Second, the sample size for the Agricultural Surveys is large enough and selected in a way that should produce statistically consistent results even with changes in the mix of respondents through the cycle.

Reduced Survey Response Rates

Another criticism of the accuracy of NASS corn stocks estimates is that the rate of response to the Agricultural Survey has declined over time, resulting in less reliable estimates of grain stocks. The magnitude of response rate is reflected in the NASS imputation rates for the Agricultural survey for the quarterly stocks estimates. When respondents fail to provide specific estimates of on-farm stocks, NASS uses available information to impute an estimate for that respondent. For example, if the respondent provides an estimate of storage capacity, an estimate of stocks can be imputed based on the average capacity-to-stocks ratio for those who provided complete information for the survey. Where no information is provided, the stocks estimate for the respondent is imputed as the average of all respondents. Figures 81 through 84 indicate that the imputation rates for the quarterly stocks reports have generally increased for corn, soybeans, and wheat since 2007 or 2008 crop years. However, the imputation rates for corn and soybeans are very similar and lower than the rates for wheat. Increased imputation rates should not have reduced the accuracy of NASS corn stocks estimates relative to soybean and wheat estimates and would not explain why some quarterly estimates resulted in surprises and did not for others. Figure 85 demonstrates directly that implied usage surprises for corn do not track imputation rates for NASS corn survey respondents. The correlation of the two series over the December 2006 through March 2012 *Grain Stocks* reports is statistically indistinguishable from zero (0.05), precisely what should be expected if the NASS surveys are unbiased with respect to imputation procedures.

Errors Associated with Increase in Number of Ethanol Plants

A concern by some market participants with NASS survey methodology for quarterly stocks estimates is associated with the increased use of corn for ethanol production. Concerns appear to stem from the timing of more frequent surprises in the stocks estimates and the growth of the ethanol industry rather than anything specific about the reporting of corn stocks by commercial facilities. Errors in estimating off-farm stocks associated with ethanol would presumably have to be the result of double counting some inventories (by ethanol plants and another entity) or the exclusion of some facilities from the reporting of grain stocks. Neither condition appears to hold. Additionally, such errors would not account for the pattern of surprises in the stocks estimates. Finally, ethanol plants tend to have limited storage capacity, generally only a few days or weeks of feedstock needs. This limits the magnitude of potential double-counting or exclusion of inventory in the NASS surveys.

Increased Corn in Transit

A concern related to the previous one is that quarterly grain stocks estimates capture grain in store, but do not attempt to estimate the amount of grain in transit. For the most part, the amount of grain in transit should be fairly constant throughout the marketing year, with some seasonal decline as soybean crush and exports and domestic corn consumption declines during the last half of the marketing year.

The amount of both corn and soybeans in transit on any particular day has likely increased over time due to increased production and consumption of those crops. In addition, the amount of corn in transit has likely been elevated due to: i) a much larger percent of consumption for ethanol production and a smaller percentage consumed as feed, and ii) a smaller percentage of feed consumption occurring at the point of production. Some have argued that recent large surprises in the quarterly stocks estimates for corn might be partially explained by an unusually large or small amount of corn in transit on the reference date for the stocks estimate. It is not clear that if that is the case, why the frequency has increased in recent years.

The fundamental question is whether there is enough corn in transit on any given day that substantial variation in that quantity would be sufficient to explain surprises in the quarterly stocks estimates. There are no data that allow the estimation of the amount of grain in transit. A rough estimate of the amount of corn in transit per day can be made based on 1) the magnitude of quarterly consumption, 2) the assumption that every bushel is transported from the location of production or initial storage to the user, and 3) equal amounts of corn are moved each day during the quarter. Corn consumption is at the peak in the first quarter of the marketing year. Consumption during the first quarter of the 2012-13 marketing year, for example, was estimated at 3.772 billion bushels. If that entire amount was transported in equal daily amounts, the in-transit quantity would have averaged 41.5 million bushels per day assuming a 7-day week and 48.3 million bushels per day assuming a 6-day week. Similar calculations for the fourth quarter of the year are 21.5 million and 25 million bushels respectively. For the 1990-91 marketing year the calculations are 21.5 and 25 million for the first quarter and 16.3 and 17 million bushels for the fourth quarter. These rough estimates of the amount of corn in transit on a given date are relatively small compared to the magnitude of the most problematic surprises in implied corn usage, which, in bushel terms (Table 27), generally are in the range of 150 to 350 million bushels.

One objection to these calculations is that transit for some corn uses, such as exports, obviously takes more than one day. This means that more corn is in transit on a given day than the figures reported above, and consequently, the magnitudes might be comparable to the large implied usage surprises. While this is undoubtedly true to some degree, this is mitigated by the fact that transit times for corn used in ethanol production generally are quite short since most ethanol plants receive corn by truck, and the market share of total corn use represented by ethanol use has risen rapidly since 2006 compared to uses that require longer transit times via barge, rail, and ocean freight. If, for example, 10 days of exports are in transit on any given day, the average total in transit amount during the quarter with the largest exports since 2009 (Mar-May 2010) would have been 90 million bushels even if all other uses required a full day's transport. The question, then, is whether there has been enough variation around that even larger estimate on the reference date for stocks estimates to explain surprises in the quarterly stocks estimates. That seems unlikely. On balance, we conclude that any variation in the amount of corn in transit on the reference date for quarterly stocks estimates is not likely to explain surprises in the estimates.

Incorrect WAOB Estimates of Corn Used for Ethanol Production

There is some disagreement about the most accurate estimate of the amount of corn used for ethanol and co-product production. The disagreement centers on two issues: i) what percent of the reported ethanol production is produced from corn? and ii) what is the industry average yield of ethanol per bushel of corn? In the case of the second issue, some have suggested that the estimate of average ethanol yield per bushel of corn used by the WAOB is too low, resulting in an over-estimate of the amount of corn used for ethanol and an under-estimate of the amount of corn used in the feed and residual category. It is then argued that this error somehow results in errors in measuring quarterly corn stocks and/or errors in forming expectations for the quarterly estimates.

The ethanol conversion argument fails for a number of reasons. First, and most importantly, there is no link between ethanol yield estimates and the magnitude of quarterly stocks. The measurement of stocks is not dependent on how corn is consumed. Second, market expectations of quarterly stocks should not be influenced by the estimate of ethanol yield. Market participants may have different expectations about the magnitude of corn consumption by category than that estimated by the USDA (e.g., less for ethanol and more for feed and residual), but the expectations of total use should not be influenced by the allocation. Third, differences in ethanol yield estimates make relatively small differences in the estimates of the amount of corn used. In an annual report for the year ended June 2013, Christianson & Associates, PLLP (Christianson, 2013), estimated that the overall industry average for undenatured ethanol yield was near 2.72 gallons per bushel, with the most efficient plants averaging 2.79 gallons and the least efficient averaging 2.65 gallons. The percentage of ethanol produced from corn and the average yield of ethanol assumed by the WAOB is not known. The simple ratio of ethanol production (including denaturant) and the WAOB estimate of corn used for ethanol production has recently been near 2.76. If it is assumed that ethanol production of about 3.3 billion gallons during a quarter is produced from corn, then an average yield of 2.76 gallons per bushel would mean that 1.196 billion bushels of corn were used for ethanol production during the quarter. A yield of 2.79 gallons per bushel would imply that about 1.183 billion bushels of corn were used while a yield of 2.65 gallons would imply that 1.245 billion bushels were used. Such differences in either direction from 1.196 billion bushels would not explain large surprises in corn stocks estimates even if there was a relationship between use in that category and the magnitude of stocks. Fourth, the lack of seasonality in ethanol production (Figure 66) means that incorrect estimates of ethanol yield should have similar implications for all quarters of the corn marketing year. However, surprises in quarterly stocks estimates have not been consistent within marketing years. Fifth, incorrect estimates of ethanol yield would not explain why surprises in stocks estimates occur in some years and not in others.

Unresolved Errors in USDA Corn Production Estimates

Market analysts have noted for some time that the occurrence of large errors in anticipating NASS quarterly grain stocks estimates could be related to January NASS estimates of production that are sometimes incorrect. More technically, large market surprises may be related to large sampling errors for January production estimates. While there is a tendency among market analysts to declare January production estimates as “final,” and therefore, having minimal errors, NASS is always careful to include a detailed discussion of potential sampling errors in production reports. For example, the *Crop Production: 2012 Summary*[21] released in January 2013 included this discussion of the reliability of production estimates:

> "The surveys used to make the acreage, yield, and production estimates contained in this report are subject to sampling and non-sampling type errors that are common to all surveys. Reliability of the objective yield and farmer survey must be treated separately because the survey designs for the two surveys are different. The objective yield indications (corn, cotton, and soybeans) are subject to sampling variability because all acres of a given commodity are not included in the sample."
>
> "The farm operator survey indications are also subject to sampling variability because not all operations with commodities of interest are included in the sample. This variability, as measured by the relative standard error at the National level, is approximately 1.1 for corn, 2.3 for Upland cotton and 1.1 for soybeans. This means that chances are approximately 95 out of 100 that survey estimates for production will be within plus or minus 2.2 percent for corn, 4.6 percent for Upland cotton, and 2.2 percent for soybeans."
>
> "Survey indications are also subject to non-sampling errors such as omission, duplication, imputation for missing data, and mistakes in reporting, recording, and processing the data. These errors cannot be measured directly, but they are minimized through rigid quality controls in the data collection process and a careful review of all reported data for consistency and reasonableness." (p.94)

The previous information implies that the range of sampling errors for corn production estimates can be surprisingly wide. With a point estimate for 2012 corn production of 10.780 billion bushels, the 95 percent confidence interval based only on the farm operator survey reliability would be 10,661 to 10,899 billion bushels (10,780 +/-1.1%), or a range of 238 million bushels. The true confidence interval is presumably even larger if one could also account for sampling variability in the objective yield survey. This discussion should make it clear that the sampling error for any particular January corn production estimate could easily be several hundred million bushels.

Some direct evidence is available on the relationship between implied usage surprises and NASS production errors. Specifically, analyst expectations for the December 1 stocks estimate are based on expected usage during the quarter and expectations about the magnitude of the January production forecast relative to the production

[21] http://usda01.library.cornell.edu/usda/nass/CropProdSu//2010s/2013/CropProdSu-01-11-2013.pdf

forecast released in November. As a result, the surprise in analyst estimates of first quarter (marketing year) usage is necessarily comingled with uncertainty regarding both usage and actual production. Regressions of the implied usage surprises for December 1 stocks estimates and the surprise in analyst expectations for the change in the NASS January production estimates show that 38 and 26 percent of the errors in anticipating December 1 stocks estimates is due to errors in anticipating production estimates for corn and soybeans, respectively. So, the surprise in the NASS January production estimates appears to be a major contributor to the surprise in the December 1 stocks estimate, particularly for corn.

Additional direct evidence in this regard is the relationship between quarterly implied usage for soybeans and revisions of previous year soybean production that NASS often makes as part of the September *Grain Stocks* report. It was noted earlier that the average absolute implied usage surprise for soybeans is largest in the fourth quarter and there is some modest statistical evidence that analysts routinely over-estimate fourth quarter soybean usage (under-estimate fourth quarter grain stocks). That relationship may be explained by the size and direction of the revision in the soybean production estimate for the previous year's harvest that is revealed in the September NASS stocks report. The production revisions are based on a nearly complete accounting of soybean usage. That is, all but a small fraction of soybean use is measured, and the measured use along with the previous January production estimate can be used to derive an ending stocks estimate for the marketing year. If the NASS September 1 stocks estimate is different from the derived stock estimate then it can be inferred that the previous year's January soybean production estimate was either too large or too small and an appropriate revision in the production estimate can be made. As Figure 86 demonstrates, much of the analyst surprise for the September stocks estimate, and the implied June-August usage, does appear to be associated with forming expectations based on incorrect production estimates. A simple correlation analysis indicates the September revision of the previous year's production estimate explains 56 percent of the analyst surprise in September. So, production revisions do indeed explain much of the surprise in the last quarter of the marketing year. Figures 87 through 89 show the same September production revisions for soybean production compared to analyst surprises in the first three quarters of the marketing year. While the relationship is generally not as strong as in the fourth quarter there is nonetheless a direct relationship for each of the earlier quarters.

In contrast to soybeans, NASS has not historically revised the previous year's production estimate for corn in association with the September stocks estimates. Since feed usage of corn is not measured, implied feed and residual use of corn in the fourth quarter of the marketing year does not provide enough information to quantify a change in the production estimate for the previous year. NASS, however, does provide revised production estimates for corn in January of the second calendar year after harvest and estimates are occasionally revised further based on Census data. We examined the relationship between the size of the revisions in the final production estimate for corn and the size of market analysts' surprise in anticipating stocks estimate for the 1990 through 2011 crop years in Figures 90 through 93. It turns out that there is almost no correlation between the production estimate revisions and implied usage surprises. For example, the production revisions explain only about four percent of the June-August implied usage surprises (associated with September 1 stock estimates). The lack of such correlation is not surprising given that the magnitude of revisions in the corn production estimates were generally very small over the 22 year period from 1990 through 2011. Those revisions exceeded one percent only once and averaged 0.25 percent in absolute terms. This stands in contrast to the revisions in the soybean production estimates that exceeded three percent twice and averaged 0.83 percent (see Figure 86). The difference in the magnitude of the revisions is sensible given that the more definitive accounting of soybean usage allows for a relatively precise final estimate of soybean production while the lack of definitive accounting of feed and residual use for corn does not provide for such a precise estimate.

In sum, unresolved errors in production estimates for corn can logically account for the surprises in the quarterly stocks and implied usage estimates. Under such circumstances, surveys for the NASS stocks estimates would presumably reveal actual crop size, while analyst expectations would be based on inaccurate production estimates or forecasts. While unresolved corn production errors can in general explain the stocks and usage surprises, we noted earlier that to have credibility any explanation needed to satisfy four criteria related to the specific pattern of surprises since 2006. We consider each of these criteria below.

1) ***Why corn and not soybeans?*** This criteria is the most straightforward to meet. As noted above, the more definitive accounting of soybean usage allows for a relatively precise final estimate of soybean production once the stock estimate for the end of the marketing year becomes available, while the lack of definitive accounting of feed and residual use for corn does not provide for such a precise estimate. So, it is quite reasonable to expect stocks/usage surprises to be larger in corn than soybeans.

   The history of soybean production revisions is also instructive from another perspective. Since corn and soybeans in the U.S. are grown in similar areas and NASS uses the same estimation procedures for the two crops, the history of soybean production revisions should provide a reasonable indication of corn production revisions if NASS were able to make such revisions. Table 35 shows the revisions of soybean production estimates in the September NASS stocks report over the 1990-2012 marketing years. This is the same set of soybean production revisions presented in Figures 86 through 89. The January soybean production estimate was revised in all but five of the years over 1990-2012 and the revisions ranged from -41 to 91 million bushels. In proportional terms, the range was -1.6 to 3.5 percent. Revisions to corn production estimates are simulated by applying the percentage soybean revisions to the average January corn production estimate over 2006-2012, 12.06 billion bushels. We use this procedure in order to scale the simulated corn revisions to production levels over 2006-2012, which is the period of greatest concern about the accuracy of NASS corn stocks estimates. As an example of the calculations, the September revision of the soybean production estimate for the 2003 marketing year is 1.5 percent. The simulated corn production revision of 180 million bushels is found by multiplying 12.06 times 1.5 percent. Figure 94 presents the simulated corn production revisions ordered from smallest to largest irrespective of marketing year. The range of the hypothetical revisions for corn is relatively large at -193 to 425 million bushels. We can compare these simulated corn production revisions with the actual bushel surprises for implied corn usage found in Table 27.[22] The key point is that magnitude of the simulated corn production revisions can be large enough to potentially explain the implied usage surprises for corn in recent years.

Further evidence in this regard is presented in Figure 95, which compares the revisions to January corn and soybean production estimates based on the most recent vintage of data in the USDA *Quick Stats* database.[23] These "final" estimates incorporate a change to estimates released in January after harvest. So, these revisions incorporate additional information compared to the soybean revisions shown in Figures 86 through 89 and corn revisions shown in Figures 90 through 93. Figure 95 clearly illustrates that soybean production estimates are routinely revised and that some of the revisions are rather large in percentage terms. In contrast, revisions in corn are very small with one exception (1997).[24]

In sum, it is reasonable to expect that January corn production estimates contain errors of a similar percentage magnitude to soybeans, given that a very similar estimation procedure is used for both crops. However, the corn revisions (estimation errors) are never realized because the accounting for corn feed and

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[22] The specific timing of the simulated revisions is not relevant in this example.

[23] http://www.nass.usda.gov/Quick_Stats/.

[24] The unusually large revision for 1997 may be related to transition of the Agricultural Census from the Department of Commerce to the USDA during 1997.

residual usage is not precise enough to provide NASS with a reliable basis for making the revisions.

2) ***Why 2006-2012 and not earlier?*** There was a notable increase in the volatility of market surprises in corn stocks estimates/implied usage starting with the 2006 marketing year and a credible explanation of the surprises needs to account for this fact. This is probably the most difficult of the four criteria to meet, since it is impossible to provide direct evidence on unobserved sampling errors. One possibility is that unresolved corn production estimation errors increased over 2006-2012 due to a series of unusual growing season weather conditions that either increased the sampling variability of production estimation or simply caused large sampling errors for particular years. Summer weather conditions in the U.S. Corn Belt for all but a few years over 1990-2005 were rather "benign" and there were relatively few large deviations from trend yields (Tannura, Irwin, and Good, 2008). It is also undoubtedly true that growing season weather during 2006-2012 tended to be more extreme. For example, 2009 saw record corn yields but an exceptionally late harvest due to excessive rainfall during the normal harvest period. As another example, the 2012 drought was among the most severe of the last century and drove corn yields far below trend (Irwin and Good, 2013). It does not seem unreasonable to conclude that sampling errors for corn production estimates would be larger under these circumstances. But, the fact remains that there is uncertainty why sampling errors increased over 2006-2012 if these errors are in fact the correct explanation for the large surprises in corn stocks/implied usage.

3) ***Why only in particular marketing years?*** The largest surprises in corn stocks estimates/implied usage were concentrated in the 2009, 2010, and 2012 marketing years. The tendency for surprises to occur in these particular years must be accounted for by a valid explanation. The most logical possibility is again larger sampling errors due to unusual growing season weather conditions during these three years. Beyond the weather observations, there is additional evidence that some kind of unique conditions were present in these three years that led to the problematic stocks/implied usage surprises. Figure 96 plots implied usage surprises in both corn and soybeans for each NASS *Grain Stocks* report during the 2006-2012 marketing years. The two highlighted areas correspond to the 2009, 2010, and 2012 marketing years. What is remarkable is the complete lack of correlation between the implied usage surprises outside of these three marketing years and then nearly perfect synchronization of the sign of the implied usage surprises across corn and soybeans within these years. Specifically, 11 out of the 12 quarters in 2009, 2010, and 2012 have the same

sign for corn and soybean implied usage surprises.[25] Note that this does not negate our earlier conclusion that implied usage surprises for soybeans over 2006-2012 tended not to be problematic; but, rather, indicates that when implied usage problems were most problematic in corn similar directional errors were observed in soybeans. Something truly unique occurred during these years and the conditions impacted both corn and soybean stocks estimates. One possibility is that there were unresolved production errors in both corn and soybeans during these years, but the errors were simply larger in corn than soybeans.

4) ***Why a pattern of reversals during marketing years?*** There was a distinct tendency towards reversals in the surprises in corn stocks estimates/implied usage within the 2009, 2010, and 2012 marketing years. This is undoubtedly a difficult criterion to meet given the specificity of the pattern. However, there is a logical explanation how unresolved errors in the production estimates for corn in these years might account for reversal of surprises. This logic can be demonstrated with the simple numerical examples shown in Table 36. It is assumed that beginning stocks are zero, the January NASS corn production estimate is 10 billion bushels, and that quarterly usage is evenly split between the quarters at 2 billion bushels. This would result in ending stocks for the marketing year of 2 billion bushels.

   Panel A of Table 36 presents a scenario where the Dec 1 stock estimate reported by NASS is 8.1 billion bushels, 100 million bushels larger than expected based on production minus expected first quarter usage (10-2=8 billion). In this scenario, analysts are assumed to correctly recognize that the 100 million bushel stocks surprise represents a production surprise. That is, the NASS January production estimate of 10 billion bushels is 100 million bushels too small. Consequently, analysts do not adjust their expectations of the rate of usage for the marketing year and simply adjust upward their estimate of stocks for the end of each of the remaining quarters by 100 million bushels. Panel B presents the same scenario in terms of the Dec 1 stocks reported by NASS, but here market analysts are assumed to mistakenly interpret the sampling error in the January production estimate as signaling that the quarterly rate of usage is 100 million bushels less than expected. The analysts lower their estimate of the quarterly rate of usage by 100 million bushels to 1.9 billion bushels. For the Mar 1 stocks estimate, analysts then expect stocks to be 6.2 billion bushels, due to the lower rate of implied usage for the September-November quarter, but NASS reports 6.1 billion bushels, reflecting the actual usage rate for the quarter of 2 billion bushels.

[25] The correlation coefficient between corn and soybean implied usage surprises during 2006-2008 and 2011 was -0.21 compared to +0.71 during 2009-2010 and 2012. The correlation in corn and soybean implied usage surprises over 1990-2005 was +0.24.

This results in a negative surprise for stocks and positive surprise for implied December-February usage, just the reverse of the sign of the surprises in the previous quarter. Moving to the June 1 stocks estimates, analysts revise their quarter usage estimates for the March-May quarter back to 2 billion bushels based on the implied usage revealed by the March 1 stocks estimate. This results in no further surprises in terms of stocks or implied usage for the marketing year.

The previous numerical example demonstrates that a reversal pattern of implied usage surprises can be generated by market analysts mistakenly viewing a stock surprise as a usage surprise when in fact the stocks surprise is the result of unresolved sampling errors in production estimates. Of course, the example is exceedingly simple and the range of possible patterns is quite large depending on market analysts' perceptions of the split between usage and production surprises for a given stock surprise and how analysts adjust usage expectations going forward. Regardless, as shown in Table 37, we can use the example as a guide for interpreting how this logic can be applied to explain the pattern of corn usage surprises for the for the 2009, 2010, and 2012 marketing years. Note that the usage surprise is computed in Table 37 as the use implied by NASS stocks estimate minus usage implied by analyst expectations. The alternating pattern of surprises in quarterly implied usage in 2009 and 2012 supports the logic outlined in the example, while the pattern in 2010 fails in the final quarter. While it is reasonable to argue that the reversal pattern of implied usage surprises can be generated by market analysts mistakenly viewing a stock surprise as a usage surprise when the surprise is the result of unresolved sampling errors in production estimates, one also has to acknowledge that the varying magnitude of surprises in implied usage through the marketing year could be associated with other factors, particularly sampling errors in the stocks estimates themselves.

Overall, the analysis presented in this section suggests that unresolved errors in production estimates for corn are the most likely explanation for the large surprises in quarterly corn stocks and implied usage estimates that were observed over 2006-2012. NASS stocks estimates undoubtedly encompass sampling errors for both production and stocks estimates and it is highly likely that unresolved sampling errors for corn production estimates are large enough to explain the surprises. It is more difficult to pin down exactly why unresolved sampling errors for corn production were concentrated in 2009, 2010, and 2012 and caused the quarter-to-quarter reversal pattern in surprises, but reasonable arguments can be put forward. Nonetheless, it is important to emphasize there is no "smoking gun" in terms of the available evidence on the impact of unresolved sampling errors, with some of the evidence best described as circumstantial.

Estimates of the Size of the Domestic Soybean Crush

Historically, the Census Bureau released a monthly report of the activity of the domestic soybean crushing industry. That report, M311J *Fats and Oils: Oilseed Crushings,* included estimates of the bushels of soybeans processed by region during the previous month; the magnitude of soybean meal and soybean oil production during the month; and the magnitude of soybean, soybean meal, and soybean oil stocks at the end of the month. Interested parties used these estimates to gauge the rate of consumption of soybeans and soybean products during the marketing year and to judge the strength of demand for those commodities. The estimates of the magnitude of the domestic crush were used to anticipate the size of the NASS quarterly estimates of soybean stocks. The Census Bureau discontinued the report after July 2011.

The National Oilseed Processors Association (NOPA) surveys its membership monthly and releases estimates of soybean crush, meal and oil production, and soybean and product stocks for those members. For the first ten months of the 2010-11 soybean marketing year, the NOPA estimates of the size of the domestic soybean crush averaged 97.5 percent of the Census Bureau estimates. That was a typical ratio for complete marketing years prior to 2010-11. Since the discontinuation of the Census Bureau estimates in July 2011, NOPA estimates are used to gauge the rate of the domestic crush, the strength of soybean and product demand, and to anticipate NASS quarterly soybean stock estimates.

The reliance on NOPA soybean crush estimates does not appear to be problematic to this point. The USDA's Economic Research Service no longer makes estimates of the quarterly soybean crush in the *Oil Crops Outlook* report. Instead, estimates of total quarterly domestic soybean consumption, including seed, feed, and, residual use, are made based on the NASS stocks estimate and estimates of net trade during the quarter. The WASDE report continues to estimate the size of the crush on a marketing year basis. NOPA soybean crush estimates appear to be a satisfactory substitute for Census estimates to this point. However, there is some concern that as time progresses, the historic relationship between NOPA and Census crush estimates may no longer provide an accurate estimate of the domestic crush on a quarterly basis, adding to the difficulty of anticipating NASS stocks estimates. The relatively small and consistent quantity of seed, feed, and residual use of soybeans means that the NASS September stocks estimates still provides an accurate estimate of the total marketing year crush.

Summary, Conclusions, and Recommendations

The United States Department of Agriculture (USDA) has a number of agencies that are involved in collecting, analyzing, forecasting, and disseminating information about the production and consumption of the corn and soybean crops (Spilka, 1983; Vogel and Bange, 1999; Lusk, 2013). Market participants rely heavily on estimates and forecasts provided by these agencies in order to form price expectations and to make business decisions. In spite of on-going efforts to maintain the quality of information provided and the transparency of the methodology used, misunderstanding, concerns, or complaints about the information provided periodically arise (e.g., USDA/ESRP, 1985; Good and Irwin, 2011). More recently (since 2006) those concerns have centered on the accuracy of the quarterly estimates of corn inventories and to a lesser extent on the methodology and accuracy of early season yield forecasts (e.g., Polansek, 2010; Pleven and McGinty, 2011). It is in that context that this review of USDA forecasts and estimates for corn and soybeans was conducted.

The statistical analysis focused on three parts of the USDA forecasting system for corn and soybean supply and demand. A summary of each part of the statistical analysis is found below:

(1) National corn and soybean yield forecasts presented in the May, June, and July *World Agricultural Supply and Demand Estimates* report provided by the World Agricultural Outlook Board (WAOB).

The evidence suggests that WAOB corn and soybean yield forecasts made in May, June, or July do not have a substantial bias. The accuracy of the forecasts also has not changed markedly over the 1993-2012 time period for either corn or soybeans. With a few exceptions, WAOB corn and soybean forecast errors since 2006 generally are within the historical range of errors. While there are instances of large forecast errors, these are readily explained by unusual weather conditions or insect problems that occurred after the forecasts were released.

(2) National corn and soybean yield and production forecasts in the August, September, October, and November *Crop Production* reports provided by the National Agricultural Statistics Service (NASS).

NASS yield forecasts for corn reveal no evidence of bias in any month over 1990-2012 and forecast errors since 2006 are well within the historical range of errors. There is some evidence of improvement in the accuracy of NASS corn yield forecasts over time. Soybean forecast errors since 2006 are also within the historical range, except for September and October 2012, and there is no statistical change in the magnitude of forecast errors for soybean yields over time. However, there is also a general tendency for soybean forecasts to be conservative, in the sense of underestimating the final yield. The downward bias is statistically significant in October and November for the entire sample period and especially pronounced in 2004-2012, when about two-thirds of the forecasts across all four release months under-estimated final yield. In addition, analysts consistently under-estimated NASS production during the first half of the sample and over-estimated production during the second half.

(3) National corn and soybean stocks estimates in the December, March, June, and September quarterly *Grain Stocks* reports provided by NASS.

The statistical evidence indicates there has been a sharp decline in market analysts' ability to anticipate actual quarterly corn usage as implied by NASS *Grain Stocks* reports since the start of the 2006 marketing year. The standard deviation of market surprises for implied corn usage in 2006-2012, 6.2 percent, was twice the standard deviation over 1990-2005, 3.1 percent. Double-digit implied usage surprises occurred three times during 2006-2012 and each one substantially exceeded the largest surprise observed over 1990-2005. The most problematic corn stocks estimates occurred in the 2009, 2010, and 2012 marketing years. Within these three problematic years there was also a clear tendency towards reversal of the surprises from quarter-to-quarter. In contrast, there was no compelling evidence of deterioration in market analysts' ability to anticipate actual quarterly soybean usage as implied by NASS *Grain Stocks* reports over 1990-2012.

Given the evidence of a sharp decline in market analysts' ability to anticipate actual quarterly corn usage since the start of the 2006 marketing year, we considered a number of potential explanations for the decline offered by various market participants. Based on the statistical evidence regarding implied usage surprises we developed four criteria that an explanation needs to satisfy in order to be credible: i) Why corn and not soybeans?, ii) Why 2006-2012 and not earlier?, iii) Why only in particular marketing years?, and iv) Why a pattern of reversals during marketing years? Using these criteria, we showed that all but one of the potential explanations offered to date clearly fails to satisfy at least one of the criteria. The explanation with the most merit is that unresolved errors in production estimates for corn led to the large surprises. NASS stocks estimates undoubtedly encompass sampling errors for both production and stocks estimates and it is likely that unresolved sampling errors for corn production estimates are large enough to explain the surprises. It is more difficult to pin down exactly why unresolved sampling errors for corn production were concentrated in 2009, 2010, and 2012 and caused the quarter-to-quarter reversal pattern in surprises, but reasonable arguments can be put forward. Nonetheless, it is important to emphasize there is no "smoking gun" in terms of the available evidence on the impact of unresolved production sampling errors, with some of the evidence best described as circumstantial.

Based on our analysis and evaluation, we offer four sets of recommendations regarding USDA corn and soybean forecasts and estimates:

(1) ***WAOB corn and soybean yield forecasts:*** While there are no obvious problems with the accuracy of these yield forecasts, the forecasts have been subject to criticism from time-to-time, because of changing methodology, perceived inappropriate period for calculating trend, or lack of sensitivity to other potential yield indicators such as crop conditions. Some of the criticism also probably reflects a lack of understanding of the forecasting methodology. In particular, some data users don't appear to be aware of the difference between the WOAB forecasting methodology and that of NASS as reflected in the *Crop Production* reports issued later in the growing season. A substantial change was apparently made in 2013 with the adoption of a crop weather regression model as the basis for producing WAOB corn and soybean yield forecasts. It is not unreasonable to anticipate that this changing menu of forecasting methods creates some confusion on the part of market participants. **We recommend that the WAOB describe in a written document the exact process used to determine corn and soybean yield forecasts for each month, including the roles of crop weather regression forecasts, subjective judgment, and any other inputs, and this document be available on the WAOB website and explicitly referenced and hyperlinked in the footnotes of the relevant supply and demand tables in May, June, and July *World Agricultural Supply and Demand Estimates* (WASDE) reports.**

(2) ***NASS corn and soybean yield forecasts:*** There is no evidence of problems with the accuracy of NASS corn yield forecasts, which have actually shown improved accuracy in recent years. However, a tendency for soybean forecasts to be conservative, in the sense of underestimating final yield, has developed in recent years. The magnitude of the bias, while not large is also non-negligible. The downward bias in soybean yields has also led to market analysts consistently being surprised in the opposite direction. Consequently, soybean forecasts by market analysts have been more accurate than NASS

forecasts at times, but market prices may be nudged in the wrong direction given the benchmark status of NASS forecasts. **We recommend that NASS institute an internal review of soybean yield forecasting procedures to determine the source of any bias and make changes needed to insure it is eliminated.**

Our review also highlighted the ongoing problem of widespread misunderstanding and confusion about the forecasting procedures used by NASS to generate corn and soybean yield forecasts. While this problem likely can never be fully solved, and we are well aware of and applaud the ongoing efforts that NASS makes to communicate with market participants, we believe more can and should be done to address the misunderstanding and confusion. **We recommend that NASS "open up the black box" for each monthly corn and soybean yield forecast as much as possible. This should include: i) presentation of state and national yield forecasts derived from the agricultural yield survey (AYS) and the objective yield survey (OYS), as well as the usual composite forecast derived from the two surveys, ii) presentation of assumptions regarding fruit weights used in deriving OYS yield forecasts during forecast months when these measurements are not available, and iii) some form of recognition of the degree to which weather and crop condition data influence composite forecasts.** We understand that these changes would represent a major shift in disclosure for NASS and that arguments can be made that forecast users prefer more informative point estimates to a wider but more accurate range of competing forecasts (Isengeldina, Irwin, and Good, 2004) or that releasing the underlying AYS and OYS forecasts would only sow more confusion (Morris and Shin, 2002). Nonetheless, it is our view that most market participants would welcome this additional information and it would greatly improve not only the understanding but the usefulness of NASS forecasts. The recommendation is especially important with respect to publishing yield forecasts based on the AYS and OYS surveys. Few market participants understand the crucial role that compensating biases play in the historical accuracy of NASS corn and soybean yield forecasts. We see no reason not to explicitly acknowledge this part of the forecasting process, especially in light of the recent publication of historical data on the biases in Nandram, Berg, and Barboza (2013). Finally, the articles by Wang et al. (2011) and Nandram, Berg, and Barboza (2013) present new methods for combining the AYS and OYS survey yield forecasts along with information based on weather and crop conditions. To date, our understanding has been that NASS corn and soybean yield forecasts did not consider either weather or crop conditions data in determining final yield forecasts. Since one of the co-authors of these studies is the Chief of the Statistical Methodology Research Branch in NASS (Barboza), the research obviously has the official sanction of NASS. If NASS has changed its procedures for determining final published yield estimates or is considering a change in procedures for the future, it is very important that market participants be made fully aware of the change.

A review of NASS corn and soybean yield estimates would be incomplete without some discussion of the ongoing technological revolution widely known as "precision agriculture." One part of this revolution is the widespread use of yield monitors to provide "real-time" data on grain yields as crops are harvested. While there certainly are issues with the accuracy of this source of yield data (Nielson, 2010), there is no reason not to expect the accuracy and availability of this data to increase substantially over time. We are unaware of any research in the public domain about how this potentially valuable source of yield data could be used in the future to improve the accuracy of NASS crop yield estimates, as well as potentially increasing the frequency of estimates. **We recommend that NASS initiate a research project to study how yield monitor data could be incorporated into crop yield estimation procedures.**

(3) ***NASS corn and soybean stock estimates:*** We thoroughly reviewed NASS survey procedures for stock estimation and determined that off-farm survey respondents are instructed to report the number of 56-pound bushels of corn and 60-pound bushels of soybeans, while similarly specific instructions are not provided to on-farm respondents. **To improve the accuracy of on-farm stock estimates, we recommend that the same instructions regarding weight per bushel that NASS provides to off-farm survey respondents also be provided to on-farm survey respondents.** Statistical evidence indicates there has been a sharp decline in market analysts' ability to anticipate actual quarterly corn usage as implied by NASS *Grain Stocks* reports since the start of the 2006 marketing year. We carefully vetted numerous explanations that have been offered by market participants for the decline and found all but one lacking in terms of one or more criteria. The explanation with the most merit is that unresolved sampling errors in production estimates for corn led to the large surprises. **We nonetheless recommend that NASS initiate an internal review of corn stock estimation procedures in an effort to determine whether methodological problems are apparent.** We recognize that this (and any other reviews) may require additional resources. In addition, we recognize that given the difficulty involved in tracking the source of corn stocks estimation errors, full resolution

may require some form of “ground-truthing” project whereby on- and off-farm measurements are cross-checked versus quantities reported for quarterly surveys. This could be a very expensive undertaking. **As an alternative, we recommend that NASS investigate the possibility of adding grain stocks questions to the Agricultural Census.** This would at least provide the opportunity to assess the accuracy of on-farm grain stocks estimates once every five years.

There is also an education issue raised by our analysis of stock/usage surprises for corn. It appears there may be limited understanding among market participants that NASS grain stocks estimates encompass sampling errors in both production and stocks, which means that considerable caution needs to be used when deriving the implications for usage of a NASS point estimate of stocks. Our analysis shows just the opposite for corn, in that stocks surprises of only a few hundred million bushels have at times changed corn prices by as much as 10 percent. **We recommend that NASS engage market participants in a discussion of this particular issue and consider what means might be available to improve the general understanding of the limits of stock estimates for implying usage.**

(4) ***Domestic usage estimates****:* Implied usage surprises in soybeans over 2006-2012 were unquestionably less problematic than in corn, and we believe the evidence strongly suggests this can be traced to the ability of NASS to revise January soybean production estimates after the end of the marketing year. NASS has not historically revised the previous year's production estimate for corn in association with the September stocks estimates. Since feed usage of corn is not measured, implied feed and residual use of corn in the fourth quarter of the marketing year does not provide enough information to quantify a change in the production estimate for the previous year. Regardless, it is reasonable to expect that January corn production estimates contain errors of a similar percentage magnitude to soybeans, given that a very similar estimation procedure is used for both crops. However, the corn revisions (estimation errors) are never realized because the accounting for corn feed and residual usage is not precise enough to provide NASS with a reliable basis for making the revisions. **We recommend that the WAOB and NASS evaluate the potential costs and benefits of adding a survey of corn feed use that would allow a fuller accounting of corn usage similar to what has been historically possible for soybeans**. We believe this is the single most important change that NASS should consider implementing in light of our report. The need for a feed usage survey in corn has long been discussed but never implemented due to the perceived expense and

complexity of such a survey. Westcott and Norton (2012, p.5) recently noted the practical challenges presented in developing a feed survey for corn, "USDA does not survey for grain used in feeding and relies on survey-based production and quarterly stocks estimates to indicate grain disappearance. Surveying for feeding would require a substantial increase in resources. Such a survey might also provide impractical, given that vast array of feeding operations that make the Nation's swine, beef cattle, dairy, broiler, layer, and turkey production sectors. These operations are diverse and use a wide and complex variety of feed production in addition to grains. There is also a significant amount of feed use of grain that occurs outside the conventional livestock, dairy, and poultry sectors and includes feeding of horses, household pets, and aquaculture, all of which present additional challenges to any comprehensive survey of grain used in feeding." While we concur that the challenges appear to be daunting, we also note that consolidation of the livestock production industry in the last 20 years may allow a feed usage survey to be implemented in a more practical and cost-effective manner than is commonly perceived. For example, a useful data series could be based on a sample of larger operations from each of the major livestock species. This would not provide an estimate of total feed usage of corn but the series would be a valuable indicator of changes over time. In any event, if it is deemed important to improve the ability of market participants to better anticipate and interpret NASS corn stock estimates, some type of a corn feed survey is likely to be the only way to accomplish this goal.

Another issue related to accounting for corn usage is the average yield of ethanol per bushel of corn. As we noted in the body of the report, variation in the industry average ethanol yield of corn is not likely to be important in explaining corn usage surprises in recent years. Nonetheless, better estimates of corn used in ethanol production would contribute to the overall accuracy of corn supply, demand, and price forecasts generated by the WAOB. **We recommend that WAOB and NASS investigate the costs and benefits of adding a survey of ethanol plants to provide more accurate estimates of corn used in ethanol production.** Compared to a feed survey, the cost of surveying ethanol plants to gather this data would be relatively low given that only 211 ethanol plants are currently operating in the

U.S.[26] A good model for this type survey is the U.S. Energy Information Administration's (EIA) monthly survey of biodiesel production.[27]

The full accounting of usage in soybeans in the past has depended on monthly Census Bureau reports of the activity of the domestic soybean crushing industry. Since the discontinuation of the Census Bureau reports in July 2011, National Oilseed Processors Association (NOPA) estimates have been used to gauge the rate of the domestic crush, the strength of soybean and product demand, and to anticipate NASS quarterly soybean stock estimates. As time progresses, the historic relationship between NOPA and Census crush estimates may no longer provide an accurate estimate of the domestic crush on a quarterly basis now that the Census crush estimates are no longer available. This may add to the difficulty of anticipating NASS soybeans stocks estimates. **We recommend that WAOB and NASS seek funding to replace the former monthly Census Bureau M311J *Fats and Oils: Oilseed Crushings* report.**

[26] This is the number of operating ethanol plants listed by the Renewable Fuels Association on their website as of January 6, 2014: http://www.ethanolrfa.org/bio-refinery-locations/.

[27] http://www.eia.gov/biofuels/biodiesel/production/

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Table 1. Bushel Errors for WAOB Yield Forecasts, U.S. Corn, 1993-2012 Marketing Years

	-----bushels per acre-----		
Marketing Year	May	June	July
1993	-22.0	-22.0	-17.3
1994	16.5	16.5	13.2
1995	-12.1	-6.2	-6.2
1996	1.1	1.1	4.1
1997	-4.3	-4.3	-4.3
1998	4.8	4.8	4.8
1999	2.0	2.0	-2.0
2000	-0.1	-0.1	-0.1
2001	1.2	1.2	1.2
2002	-8.6	-6.5	-6.5
2003	2.5	2.5	-0.5
2004	15.3	15.3	15.3
2005	-0.1	-0.1	2.9
2006	0.1	0.1	0.1
2007	0.4	0.4	0.4
2008	0.0	5.0	5.5
2009	9.3	11.3	11.3
2010	-10.7	-10.7	-10.7
2011	-11.5	-11.5	-11.5
2012	-42.6	-42.6	-22.6

Note: The error is defined as the final NASS January yield estimate minus the WAOB forecast. So, a positive (negative) error results when the WAOB forecast is less (greater) than the NASS January estimate.

Table 2. Bushel Errors for WAOB Yield Forecasts, U.S. Soybeans, 1993-2012 Marketing Years

	-----bushels per acre-----		
Marketing Year	May	June	July
1993	-2.5	-2.5	-1.5
1994	6.4	6.4	5.9
1995	-1.2	-0.7	-0.7
1996	0.6	0.9	0.9
1997	0.4	0.4	0.4
1998	-0.6	-0.6	-0.6
1999	-3.4	-3.4	-3.4
2000	-1.9	-1.9	-1.9
2001	0.1	0.1	0.1
2002	-1.7	-1.7	-1.7
2003	-5.8	-5.8	-5.8
2004	2.2	2.2	2.3
2005	3.2	3.2	3.2
2006	2.2	2.2	2.2
2007	0.2	0.2	0.2
2008	-2.4	-2.4	-1.9
2009	1.4	1.4	1.4
2010	0.6	0.6	0.6
2011	-1.9	-1.9	-1.9
2012	-4.3	-4.3	-0.9

Note: The error is defined as the final NASS January yield estimate minus the WAOB forecast. So, a positive (negative) error results when the WAOB forecast is less (greater) than the NASS January estimate.

Table 3. Average Percent Errors for WAOB Yield Forecasts, U.S. Corn, 1993-2012 Marketing Years

Marketing Years	May	June	July
1993-2000	-2.27	-1.62	-1.41
t-statistic	-0.63	-0.47	-0.51
p-value	0.55	0.65	0.63
2001-2012	-3.16	-2.65	-1.28
t-statistic	-0.99	-0.82	-0.60
p-value	0.35	0.43	0.56
1993-2012	-2.80	-2.24	-1.33
t-statistic	-1.20	-0.96	-0.80
p-value	0.25	0.35	0.43

Note: t-statistic tests for difference from zero.

Table 4. Average Absolute Percent Errors for WAOB Yield Forecasts, U.S. Corn, 1993-2012 Marketing Years

Marketing Years	May	June	July
1993-2012	6.40	6.28	5.28
1993-2000	6.73	6.08	5.49
2001-2012	6.18	6.42	5.14
t-statistic	-0.14	0.09	-0.14
p-value	0.89	0.93	0.89
1993-2012 Trend	0.09	0.19	0.04
t-statistic	0.27	0.57	0.20
p-value	0.79	0.58	0.84

Note: The first t-statistic tests for difference in means between samples and the second t-statistic tests whether the trend is different from zero.

Table 5. Average Percent Errors for WAOB Yield Forecasts, U.S. Soybeans, 1993-2012 Marketing Years

Marketing Years	May	June	July
1993-2000	-1.10	-0.82	-0.59
t-statistic	-0.40	-0.30	-0.24
p-value	0.70	0.77	0.82
2001-2012	-1.67	-1.67	-0.83
t-statistic	-0.80	-0.80	-0.44
p-value	0.44	0.44	0.67
1993-2012	-1.44	-1.33	-0.73
t-statistic	-0.89	-0.82	-0.50
p-value	0.38	0.42	0.62

Note: t-statistic tests for difference from zero.

Table 6. Average Absolute Percent Errors for WAOB Yield Forecasts, U.S. Soybeans, 1993-2012 Marketing Years

Marketing Years	May	June	July
1993-2012	5.55	5.52	4.83
1993-2000	5.62	5.54	5.01
2001-2012	5.51	5.51	4.71
t-statistic	-0.05	-0.02	-0.14
p-value	0.89	0.93	0.89
1993-2012 Trend	-0.06	-0.05	-0.12
t-statistic	-0.31	-0.27	-0.72
p-value	0.76	0.79	0.48

Note: The first t-statistic tests for difference in means between samples and the second t-statistic tests whether the trend is different from zero.

Table 7. Bushel Errors for NASS Yield Forecast, U.S. Corn, 1990-2012 Marketing Years

	-----bushels per acre-----			
Marketing Year	August	September	October	November
1990	0.8	-3.2	-1.8	-0.5
1991	0.8	2.5	-0.2	-0.3
1992	10.2	10.1	7.7	2.2
1993	-15.3	-12.4	-9.6	-2.4
1994	10.2	9.6	4.8	0.2
1995	-12.1	-7.6	-3.1	-0.2
1996	8.4	6.9	4.1	0.6
1997	1.4	1.5	0.9	0.3
1998	4.4	2.4	2.4	1.4
1999	-0.9	1.6	0.3	-0.7
2000	-5.0	-4.9	-2.7	-0.8
2001	4.3	4.7	1.9	0.2
2002	4.1	3.9	2.1	1.7
2003	2.3	3.7	0.0	-1.0
2004	11.4	10.9	1.9	0.1
2005	8.7	4.7	1.8	-0.5
2006	-3.1	-5.6	-4.4	-2.1
2007	-2.1	-5.1	-4.0	-2.3
2008	-1.1	1.6	0.0	0.1
2009	5.2	2.8	0.5	1.8
2010	-12.2	-9.7	-3.0	-1.5
2011	-5.8	-0.9	-0.9	0.5
2012	0.0	0.6	1.4	1.1

Note: The error is defined as the NASS January final yield estimate minus the NASS forecast. So, a positive (negative) error results when the NASS forecast is less (greater) than the NASS January final yield estimate.

Table 8. Bushel Errors for NASS Yield Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

	-----bushels per acre-----			
Marketing Year	August	September	October	November
1990	1.6	1.7	1.8	0.4
1991	2.4	3.2	1.2	0.7
1992	1.8	1.7	1.3	0.3
1993	-1.2	-1.4	-1.1	-0.1
1994	3.8	3.2	0.9	-0.1
1995	-1.1	-1.7	-0.2	-0.1
1996	1.4	1.8	0.6	-0.3
1997	-0.4	-0.4	-0.1	-0.3
1998	-0.6	-1.7	0.2	0.3
1999	-2.6	-1.3	-0.4	-0.1
2000	-2.6	-1.4	-0.6	0.1
2001	0.9	1.4	0.4	0.2
2002	1.5	1.0	1.0	0.5
2003	-5.5	-2.5	-0.1	0.1
2004	3.1	3.7	0.2	-0.4
2005	4.4	3.5	1.5	0.4
2006	3.3	1.1	0.1	-0.1
2007	0.2	0.3	0.3	0.4
2008	-0.8	-0.3	0.2	0.4
2009	2.3	1.7	1.6	0.7
2010	-0.5	-1.2	-0.9	-0.4
2011	0.1	-0.3	0.0	0.2
2012	3.5	4.3	1.8	0.3

Note: The error is defined as the NASS January final yield estimate minus the NASS forecast. So, a positive (negative) error results when the NASS forecast is less (greater) than the NASS January final yield estimate.

Table 9. Average Percent Errors for NASS Yield Forecasts, U.S. Corn, 1990-2012 Marketing Years

Marketing Years	August	September	October	November
1990-2000	-0.24	0.11	-0.06	-0.07
t-statistic	-0.11	0.06	-0.05	-0.23
p-value	0.91	0.95	0.96	0.82
2001-2012	0.66	0.68	-0.11	-0.09
t-statistic	0.54	0.64	-0.24	-0.32
p-value	0.60	0.54	0.81	0.75
1990-2012	0.23	0.41	-0.09	-0.08
t-statistic	0.19	0.40	-0.14	-0.40
p-value	0.85	0.69	0.89	0.69

Note: t-statistic tests for difference from zero.

Table 10. Average Absolute Percent Errors for NASS Yield Forecasts, U.S. Corn, 1990-2012 Marketing Years

Marketing Years	August	September	October	November
1990-2012	4.25	3.83	2.01	0.73
1990-2000	5.24	4.71	2.84	0.72
2001-2012	3.35	3.03	1.25	0.74
t-statistic	-1.18	-1.41	-1.81	0.07
p-value	0.26	0.18	0.10	0.95
1990-2012 Trend	-0.16	-0.18	-0.13	0.00
t-statistic	-1.37	-2.16	-2.15	0.00
p-value	0.18	0.04	0.04	1.00

Note: The first t-statistic tests for difference in means between samples and the second t-statistic tests whether the trend is different from zero.

Table 11. Average Percent Errors for NASS Yield Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

Marketing Years	August	September	October	November
1990-2000	0.55	0.88	0.88	0.22
t-statistic	0.33	0.54	1.13	0.81
p-value	0.75	0.60	0.29	0.44
2001-2012	2.24	2.45	1.24	0.48
t-statistic	1.09	1.65	2.23	2.04
p-value	0.30	0.13	0.05	0.07
1990-2012	1.43	1.70	1.07	0.35
t-statistic	1.09	1.56	2.31	2.01
p-value	0.29	0.13	0.03	0.06

Note: t-statistic tests for difference from zero.

Table 12. Average Absolute Percent Errors for NASS Yield Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

Marketing Years	August	September	October	November
1990-2012	5.15	4.60	1.87	0.77
1990-2000	4.79	4.83	2.13	0.70
2001-2012	5.47	4.39	1.63	0.83
t-statistic	0.43	-0.37	-0.75	0.63
p-value	0.67	0.71	0.46	0.53
1990-2012 Trend	-0.02	-0.08	-0.06	0.00
t-statistic	-0.15	-0.84	-1.19	0.00
p-value	0.88	0.41	0.25	1.00

Note: The first t-statistic tests for difference in means between samples and the second t-statistic tests whether the trend is different from zero.

Table 13. Average Absolute Percent Errors for WAOB and NASS Yield Forecasts, U.S. Corn, 1993-2012 Marketing Years

	-----WAOB-----			-----NASS-----			
Marketing Years	**May**	**June**	**July**	**August**	**September**	**October**	**November**
1993-2012	6.40	6.28	5.28	4.43	3.77	1.93	0.72
1993-2000	6.73	6.08	5.49	6.07	4.89	2.96	0.70
2001-2012	6.18	6.42	5.14	3.35	3.03	1.25	0.74
t-statistic	-0.14	0.09	-0.14	-1.43	-1.27	-1.61	0.14
p-value	0.89	0.93	0.89	0.19	0.24	0.15	0.89

Note: the t-statistic tests for difference in means between samples.

Table 14. Average Absolute Percent Errors for WAOB and NASS Yield Forecasts, U.S. Soybeans, 1993-2012 Marketing Years

	-----WAOB-----			-----NASS-----			
Marketing Years	**May**	**June**	**July**	**August**	**September**	**October**	**November**
1993-2012	5.55	5.52	4.83	5.09	4.35	1.54	0.68
1993-2000	5.62	5.54	5.01	4.52	4.28	1.39	0.46
2001-2012	5.51	5.51	4.71	5.47	4.39	1.63	0.83
t-statistic	-0.05	-0.02	-0.14	0.55	0.09	0.41	2.46
p-value	0.89	0.93	0.89	0.58	0.93	0.68	0.02

Note: the t-statistic tests for difference in means between samples.

Table 15. Bushel Market Surprises for NASS Production Forecasts, U.S. Corn, 1990-2012 Marketing Years

	-----millions of bushels-----				
Marketing Year	August	September	October	November	January
1990	-125	166	135	-33	-1
1991	-32	-29	-32	-46	-7
1992	-259	-117	-62	-26	156
1993	-81	-161	-7	-188	-84
1994	-226	-14	-147	23	-31
1995	239	-152	82	-85	25
1996	-339	-38	-51	84	-21
1997	-287	-46	-28	57	-4
1998	56	150	46	-36	-69
1999	308	49	-4	35	-109
2000	185	178	133	54	-1
2001	-55	110	74	35	-60
2002	-140	1	168	-6	-9
2003	-268	79	321	-44	-183
2004	100	-2	-64	28	54
2005	73	267	-243	60	44
2006	150	82	-165	-39	-171
2007	55	83	124	-59	-35
2008	302	-82	25	-55	119
2009	289	94	-286	-19	332
2010	83	-39	-38	-16	-44
2011	-169	-8	108	-71	78
2012	-192	324	0	96	154

Note: The market surprise is defined as the NASS reported production forecast minus the average analyst forecast. So, a positive (negative) surprise results when the average analyst forecast is less (greater) than the NASS reported production.

Table 16. Bushel Market Surprises for NASS Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

	-----millions of bushels-----				
Marketing Year	August	September	October	November	January
1990	-30	-1	-3	13	15
1991	42	12	85	-10	19
1992	-56	-4	-22	-11	31
1993	15	37	34	-28	-14
1994	-31	38	19	-20	20
1995	84	95	32	22	-24
1996	53	10	40	28	-27
1997	45	-3	-21	14	-6
1998	11	25	-97	-37	-13
1999	-23	26	-37	-10	-23
2000	35	38	-5	18	25
2001	-27	2	58	6	-33
2002	-66	-31	-26	-38	42
2003	-109	-114	-122	-12	-33
2004	-78	-55	44	7	-8
2005	-16	29	-38	9	25
2006	-118	-8	-21	-39	-47
2007	-52	-38	-50	-23	1
2008	-28	-14	63	2	49
2009	-14	-4	-41	57	24
2010	67	77	-83	-58	-47
2011	-118	60	-21	-2	14
2012	-94	-4	90	80	16

Note: The market surprise is defined as the NASS reported production minus the average analysts forecast. So, a positive (negative) surprise results when the average analyst forecast is less (greater) than the NASS reported production.

Table 17. Average Percent Market Surprise for NASS Production Forecasts, U.S. Corn, 1990-2012 Marketing Years

Marketing Years	August	September	October	November	January
1990-2000	-0.63	-0.10	-0.14	-0.28	-0.17
t-statistic	-0.85	-0.24	-0.49	-0.88	-0.72
p-value	0.42	0.82	0.63	0.40	0.49
2001-2012	0.07	0.71	0.19	-0.05	0.14
t-statistic	0.15	2.24	0.42	-0.35	0.39
p-value	0.89	0.05	0.69	0.73	0.71
1990-2012	-0.27	0.32	0.03	-0.16	-0.01
t-statistic	-0.62	1.17	0.10	-0.96	-0.05
p-value	0.54	0.25	0.92	0.35	0.96

Note: t-statistic tests for difference from zero.

Table 18. Average Absolute Percent Market Surprise for NASS Production Forecasts, U.S. Corn, 1990-2012 Marketing Years

Marketing Years	August	September	October	November	January
1990-2012	1.77	1.02	1.02	0.56	0.74
1990-2000	2.18	1.16	0.73	0.76	0.53
2001-2012	1.39	0.89	1.29	0.39	0.94
t-statistic	-1.90	-0.74	1.82	-1.55	1.40
p-value	0.07	0.46	0.07	0.15	0.17
1990-2012 Trend	-0.04	-0.01	0.02	-0.02	0.03
t-statistic	-1.17	-0.51	0.81	-1.38	1.51
p-value	0.25	0.61	0.42	0.18	0.15

Note: The first t-statistic tests for difference in means between samples and the second t-statistic tests whether the trend is different from zero.

Table 19. Average Percent Market Surprise for NASS Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

Marketing Years	August	September	October	November	January
1990-2000	0.53	1.05	0.28	-0.10	0.02
t-statistic	0.89	2.78	0.45	-0.35	0.08
p-value	0.39	0.02	0.66	0.74	0.94
2001-2012	-1.94	-0.39	-0.46	-0.05	0.01
t-statistic	-3.70	-0.76	-0.70	-0.13	0.03
p-value	0.00	0.46	0.50	0.90	0.98
1990-2012	-0.76	0.30	-0.10	-0.07	0.02
t-statistic	-1.63	0.86	-0.23	-0.31	0.07
p-value	0.12	0.40	0.82	0.76	0.94

Note: t-statistic tests for difference from zero.

Table 20. Average Absolute Percent Market Surprise for NASS Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

Marketing Years	August	September	October	November	January
1990-2012	1.99	1.18	1.73	0.86	0.91
1990-2000	1.70	1.11	1.55	0.81	0.85
2001-2012	2.26	1.25	1.90	0.91	0.95
t-statistic	1.12	0.28	0.65	0.37	0.51
p-value	0.26	0.78	0.52	0.71	0.61
1990-2012 Trend	0.03	0.01	0.02	0.02	0.00
t-statistic	0.85	0.15	0.38	1.09	-0.23
p-value	0.41	0.88	0.71	0.29	0.82

Note: The first t-statistic tests for difference in means between samples and the second t-statistic tests whether the trend is different from zero.

Table 21. Average Absolute Percent Error for NASS and Market Analyst Production Forecasts, U.S. Corn, 1990-2012 Marketing Years

Marketing Years	August	September	October	November
Panel A: 1990-2012				
NASS	4.31	3.72	2.02	0.80
Market Analysts	4.03	4.04	2.72	1.14
Difference	0.28	-0.32	-0.69	-0.34
T-statistic	0.79	-1.20	-3.29	-2.17
p-value	0.44	0.24	0.00	0.04
Panel B: 1990-2000				
NASS	5.43	4.71	2.74	0.75
Market Analysts	4.43	4.72	3.20	1.30
Difference	1.00	-0.01	-0.46	-0.55
T-statistic	1.82	-0.06	-1.84	-1.79
p-value	0.10	0.95	0.10	0.10
Panel C: 2001-2012				
NASS	3.29	2.81	1.36	0.85
Market Analysts	3.66	3.41	2.27	1.00
Difference	-0.37	-0.60	-0.91	-0.15
T-statistic	-1.08	-1.87	-2.75	-1.34
p-value	0.30	0.09	0.02	0.21

Note: t-statistic is for a pair-wise difference in means test.

Table 22. Average Absolute Percent Error for NASS and Market Analyst Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

Marketing Years	August	September	October	November
Panel A: 1990-2012				
NASS	5.60	5.13	2.21	0.99
Market Analysts	5.16	4.86	3.11	1.32
Difference	0.44	0.27	-0.90	-0.33
T-statistic	0.93	0.77	-2.32	-1.60
p-value	0.36	0.45	0.03	0.12
Panel B: 1990-2000				
NASS	5.37	5.46	2.56	0.96
Market Analysts	4.82	4.79	3.25	1.00
Difference	0.55	0.67	-0.69	-0.05
T-statistic	1.00	1.40	-1.19	-0.18
p-value	0.34	0.19	0.26	0.86
Panel C: 2001-2012				
NASS	5.81	4.83	1.89	1.02
Market Analysts	5.47	4.92	2.98	1.62
Difference	0.34	-0.09	-1.09	-0.60
T-statistic	0.43	-0.18	-2.03	-1.91
p-value	0.68	0.86	0.07	0.08

Note: t-statistic is for a pair-wise difference in means test.

Table 23. Bushel Market Surprises for NASS Stocks Estimates, U.S. Corn, 1990-2012 Marketing Years

	-----millions of bushels-----			
Marketing Year	**Dec. 1**	**March 1**	**June 1**	**Sept. 1**
1990	-160	20	77	-12
1991	-91	116	-38	-17
1992	139	29	-16	6
1993	-97	20	70	-7
1994	-143	-9	6	95
1995	-28	-81	-162	16
1996	-115	-81	14	-46
1997	-196	102	80	-90
1998	-68	78	32	105
1999	-243	33	100	-49
2000	93	-11	-26	-41
2001	-62	56	-14	-33
2002	126	-68	-28	66
2003	-256	-19	39	5
2004	157	32	-102	-54
2005	38	0	1	4
2006	-177	47	67	157
2007	-281	-217	103	78
2008	239	-45	76	-45
2009	243	185	-303	301
2010	-57	-178	346	166
2011	241	-142	-33	-138
2012	-180	386	-92	143

Note: The surprise is defined as the NASS reported stocks minus the average analyst estimate. So, a positive (negative) surprise results when the average analyst estimate is less (greater) than the NASS reported stocks.

Table 24. Bushel Market Surprise for NASS Stocks Estimates, U.S. Soybeans, 1990-2012 Marketing Years

	-----millions of bushels-----			
Marketing Year	**Dec. 1**	**March 1**	**June 1**	**Sept. 1**
1990	11	16	0	5
1991	-84	1	8	-3
1992	1	-15	-22	14
1993	-7	8	26	49
1994	-20	-70	12	-20
1995	-25	14	28	19
1996	-60	-34	-16	17
1997	-37	-27	-45	6
1998	-21	-35	2	-22
1999	-28	-23	-1	22
2000	31	-24	-27	19
2001	-57	-8	-5	18
2002	36	12	46	21
2003	-64	39	16	-7
2004	-8	-39	-14	-37
2005	60	-9	-22	-33
2006	-39	-17	15	21
2007	61	76	7	61
2008	95	-20	11	27
2009	-74	63	-21	0
2010	-56	-46	22	-10
2011	54	11	27	37
2012	-18	64	-6	17

Note: The surprise is defined as the NASS reported stocks minus the average analyst estimate. So, a positive (negative) surprise results when the average analyst estimate is less (greater) than the NASS reported stocks.

Table 25. Average Percent Market Surprise in NASS Stock Estimates, U.S. Corn, 1990-2012 Marketing Years

Measure	Dec. 1	March 1	June 1	Sept. 1
Percent Surprise	-0.59	0.21	0.11	2.08
t-statistic	-1.50	0.47	0.15	1.29
p-value	0.15	0.64	0.89	0.21
Absolute Percent Surprise	0.21	1.50	2.46	5.68
Proportion in Range	0.48	0.70	0.78	0.48

Note: The t-statistic tests for difference from zero. Proportion in Range is the percent of reported stocks that fell within the range of market analyst estimates.

Table 26. Average Percent Market Surprise in NASS Stock Estimates, U.S. Soybeans, 1990-2012 Marketing Years

Measure	Dec. 1	March 1	June 1	Sept. 1
Percent Surprise	-0.62	-0.07	0.32	5.82
t-statistic	-1.31	-0.11	0.44	2.50
p-value	0.21	0.91	0.66	0.02
Absolute Percent Surprise	1.95	2.34	2.75	9.81
Proportion in Range	0.61	0.61	0.70	0.43

Note: The t-statistic tests for difference from zero. Proportion in Range is the percent of reported stocks that fell within the range of market analyst estimates.

Table 27. Bushel Market Surprise for NASS Implied Usage Estimates, U.S. Corn, 1990-2012 Marketing Years

		-----millions of bushels-----		
Marketing Year	Sept.-Nov.	Dec.-Feb.	Mar.-May	Jun.-Aug.
1990	159	-20	-77	12
1991	84	-116	38	17
1992	17	-29	16	-6
1993	13	-20	-70	7
1994	112	9	-6	-95
1995	53	81	162	-16
1996	94	81	-14	46
1997	192	-102	-80	90
1998	-1	-78	-32	-105
1999	134	-33	-100	49
2000	-94	11	26	41
2001	2	-56	14	33
2002	-135	68	28	-66
2003	73	19	-39	-5
2004	-103	-32	102	54
2005	6	0	-1	-4
2006	6	-47	-67	-157
2007	246	217	-103	-78
2008	-120	45	-76	45
2009	89	-185	303	-301
2010	13	178	-346	-166
2011	-163	142	33	138
2012	334	-386	92	-143

Note: The surprise is defined as the NASS implied usage estimate minus the average analyst implied usage estimate. So, a positive (negative) surprise results when the average analyst implied usage estimate is less (greater) than the NASS implied usage.

Table 28. Bushel Market Surprise for NASS Implied Usage Estimates, U.S. Soybeans, 1990-2012 Marketing Years

	-----millions of bushels-----			
Marketing Year	Sept.-Nov.	Dec.-Feb.	Mar.-May	Jun.-Aug.
1990	4	-16	0	-5
1991	103	-1	-8	3
1992	30	15	22	-14
1993	-7	-8	-26	-49
1994	40	70	-12	20
1995	1	-14	-28	-19
1996	33	34	16	-17
1997	31	27	45	-6
1998	8	35	-2	22
1999	5	23	1	-22
2000	-6	24	27	-19
2001	24	8	5	-18
2002	6	-12	-46	-21
2003	31	-39	-16	7
2004	0	39	14	37
2005	-35	9	22	33
2006	-8	17	-15	-21
2007	-60	-76	-7	-61
2008	-46	20	-11	-27
2009	98	-63	21	0
2010	9	46	-22	10
2011	-40	-11	-27	-37
2012	34	-64	6	-17

Note: The surprise is defined as the NASS implied usage estimate minus the average analyst implied usage estimate. So, a positive (negative) surprise results when the average analyst implied usage estimate is less (greater) than the NASS implied usage.

Table 29. Average Percent Market Surprise for NASS Implied Usage Estimates, U.S. Corn, 1990-2012 Marketing Years

Marketing Years	Sep.-Nov.	Dec.-Feb.	Mar.-May	Jun.-Aug.
1990-2000	2.55	-0.96	-0.76	0.23
t-statistic	2.92	-1.10	-0.67	0.23
p-value	0.02	0.30	0.52	0.82
2001-2012	0.42	-0.44	-0.26	-2.28
t-statistic	0.35	-0.27	-0.18	-1.54
p-value	0.73	0.79	0.86	0.15
1990-2012	1.44	-0.69	-0.50	-1.08
t-statistic	1.89	-0.75	-0.54	-1.16
p-value	0.07	0.46	0.59	0.26

Note: t-statistic tests for difference from zero.

Table 30. Average Absolute Percent Market Surprise for NASS Implied Usage Estimates, U.S. Corn, 1990-2012 Marketing Years

Marketing Years	Sep.-Nov.	Dec.-Feb.	Mar.-May	Jun.-Aug.
1990-2012	3.02	3.11	3.25	3.45
1990-2000	3.09	2.36	2.92	2.50
2001-2012	2.95	3.81	3.55	4.31
t-statistic	-0.14	1.10	0.49	1.50
p-value	0.89	0.27	0.62	0.14
1990-2012 Trend	0.03	0.19	0.11	0.24
t-statistic	0.38	2.09	1.15	3.08
p-value	0.71	0.05	0.26	0.01

Note: The first t-statistic tests for difference in means between samples and the second t-statistic tests whether the trend is different from zero.

Table 31. Percent Market Surprise for NASS Implied Usage Estimates, U.S. Corn, 1990-2012 Marketing Years

		-----percent surprise-----		
Marketing Year	Sept.-Nov.	Dec.-Feb.	Mar.-May	Jun.-Aug.
1990	6.80	-0.93	-4.28	0.82
1991	3.42	-5.86	2.09	1.04
1992	0.64	-1.30	0.81	-0.38
1993	0.52	-1.03	-4.28	0.46
1994	3.90	0.36	-0.28	-5.11
1995	1.87	3.52	7.78	-1.24
1996	3.34	3.36	-0.70	2.86
1997	6.36	-4.45	-4.22	5.21
1998	-0.04	-3.29	-1.54	-5.79
1999	4.17	-1.37	-4.95	2.61
2000	-2.96	0.43	1.22	2.04
2001	0.06	-2.29	0.64	1.63
2002	-4.54	2.71	1.30	-3.46
2003	2.25	0.72	-1.68	-0.23
2004	-3.10	-1.18	4.19	2.44
2005	0.18	-0.01	-0.02	-0.15
2006	0.17	-1.63	-2.63	-7.03
2007	6.00	6.37	-3.64	-3.25
2008	-3.31	1.43	-2.81	1.73
2009	2.30	-5.70	8.96	-11.55
2010	0.32	5.07	-12.13	-6.53
2011	-4.24	3.90	1.15	6.37
2012	8.92	-14.66	3.49	-7.37

Note: The surprise is defined as the NASS implied usage estimate minus the average analyst implied usage estimate. So, a positive (negative) surprise results when the average analyst implied usage estimate is less (greater) than the NASS implied usage. Surprises that are 5 percent or more in absolute value are highlighted in yellow.

Table 32. Average Percent Market Surprise for NASS Implied Usage Estimates, U.S. Soybeans, 1990-2012 Marketing Years

Marketing Years	Sep.-Nov.	Dec.-Feb.	Mar.-May	Jun.-Aug.
1990-2000	3.50	2.13	0.30	-2.56
t-statistic	2.03	1.91	0.25	-1.67
p-value	0.07	0.09	0.81	0.13
2001-2012	-0.25	-1.15	-1.06	-2.15
t-statistic	-0.20	-0.91	-1.13	-1.21
p-value	0.85	0.38	0.28	0.25
1990-2012	1.54	0.42	-0.41	-2.35
t-statistic	1.39	0.47	-0.54	-2.04
p-value	0.18	0.64	0.59	0.05

Note: t-statistic tests for difference from zero.

Table 33. Average Absolute Percent Market Surprise for NASS Implied Usage Estimates, U.S. Soybeans, 1990-2012 Marketing Years

Marketing Years	Sep.-Nov.	Dec.-Feb.	Mar.-May	Jun.-Aug.
1990-2012	3.63	3.50	2.90	4.84
1990-2000	3.87	3.41	3.04	4.29
2001-2012	3.41	3.58	2.76	5.35
t-statistic	-0.25	0.17	-0.30	0.72
p-value	0.80	0.87	0.77	0.48
1990-2012 Trend	-0.08	0.06	-0.03	0.08
t-statistic	-0.60	0.83	-0.40	0.75
p-value	0.56	0.41	0.69	0.46

Note: The first t-statistic tests for difference in means between samples and the second t-statistic tests whether the trend is different from zero.

Table 34. Percent Market Surprise for NASS Implied Usage Estimates, U.S. Soybeans, 1990-2012 Marketing Years

	-----percent surprise-----			
Marketing Year	Sept.-Nov.	Dec.-Feb.	Mar.-May	Jun.-Aug.
1990	0.84	-3.24	0.00	-1.27
1991	19.18	-0.17	-1.66	0.72
1992	4.68	2.42	4.14	-3.58
1993	-1.28	-1.47	-5.74	-14.16
1994	6.01	9.58	-2.08	4.38
1995	0.15	-2.17	-5.22	-4.04
1996	4.45	4.43	2.87	-4.63
1997	3.59	3.41	7.38	-1.47
1998	1.07	4.77	-0.37	4.38
1999	0.59	2.93	0.16	-4.45
2000	-0.74	2.90	3.83	-4.07
2001	2.81	0.85	0.80	-3.82
2002	0.67	-1.29	-7.73	-4.95
2003	3.40	-4.93	-3.14	2.19
2004	0.01	4.22	2.11	8.44
2005	-4.22	1.13	3.22	6.14
2006	-0.90	1.83	-2.18	-4.01
2007	-7.29	-8.44	-0.94	-12.96
2008	-5.13	2.09	-1.57	-5.93
2009	8.46	-5.91	3.00	-0.03
2010	0.76	4.49	-3.51	2.47
2011	-4.39	-1.13	-3.90	-7.51
2012	2.82	-6.65	1.06	-5.78

Note: The surprise is defined as the NASS implied usage estimate minus the average analyst implied usage estimate. So, a positive (negative) surprise results when the average analyst implied usage estimate is less (greater) than the NASS implied usage. Surprises that are 5 percent or more in absolute value are highlighted in yellow.

Table 35. NASS January and Following September Estimates of U.S. Soybean Production, 1990-2012 Marketing Years

Marketing Year	January Estimate (mil. bu.)	Revised September Estimate (mil. bu.)	September Revision (mil. bu.)	September Revision (%)
90	1,922	1,926	4	0.2
91	1,986	1,987	1	0.1
92	2,197	2,188	-9	-0.4
93	1,809	1,869	60	3.3
94	2,558	2,517	-41	-1.6
95	2,152	2,177	25	1.2
96	2,382	2,382	0	0.0
97	2,727	2,703	-24	-0.9
98	2,757	2,741	-16	-0.6
99	2,643	2,654	11	0.4
00	2,770	2,758	-12	-0.4
01	2,891	2,891	0	0.0
02	2,730	2,749	19	0.7
03	2,418	2,454	36	1.5
04	3,141	3,124	-17	-0.5
05	3,086	3,063	-23	-0.7
06	3,188	3,188	0	0.0
07	2,585	2,676	91	3.5
08	2,959	2,967	8	0.3
09	3,361	3,361	0	0.0
10	3,329	3,329	0	0.0
11	3,056	3,094	38	1.2
12	3,015	3,034	19	0.6
		Min.	-41	-1.6
		Max.	91	3.5
		St. Dev.	29.0	1.2

Note: The hypothetical revisions for U.S. corn production are the product of the assumed constant production of 13,000 million bushels and the percentage September revision of U.S. soybean production in each year.

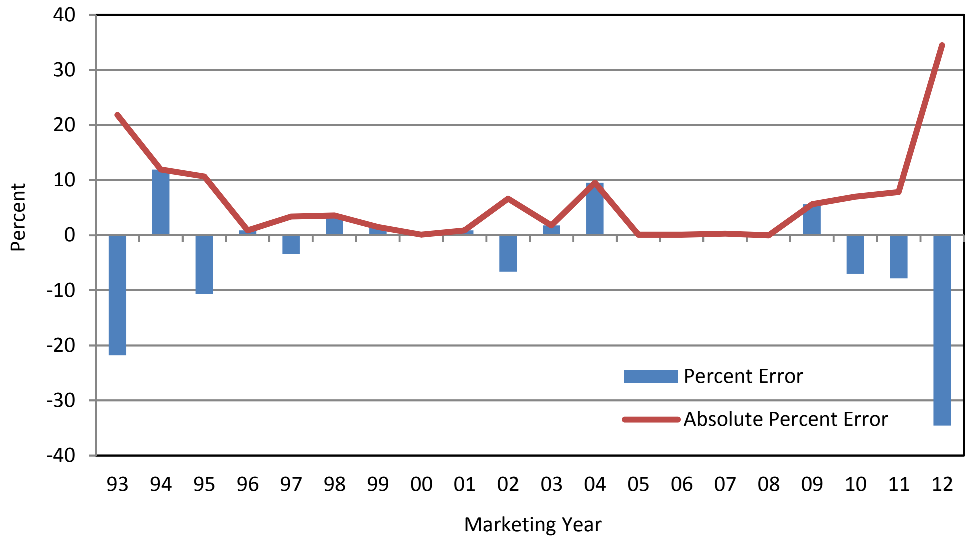
Table 36. Numerical Examples of Analyst Interpretation of Quarterly NASS Stock Estimates for Corn

Stocks Report Reference Date	Expected Stocks	Actual Stocks	Stocks Surprise	Production Surprise	Expected Use	Analyst Implied Use	Use Surprise	Actual Use	End of Year Stocks
				---billion bushels---					
Panel A: Correct Interpretation of Production Surprise									
Dec. 1	8.0	8.1	0.1	0.1	2.0	2.0	0.0	2.0	2.1
Mar. 1	6.1	6.1	0.0	0.0	2.0	2.0	0.0	2.0	2.1
Jun. 1	4.1	4.1	0.0	0.0	2.0	2.0	0.0	2.0	2.1
Sep. 1	2.1	2.1	0.0	0.0	2.0	2.0	0.0	2.0	2.1
Panel B: Incorrect Interpretation of Production Surprise									
Dec. 1	8.0	8.1	0.1	0.0	2.0	1.9	-0.1	2.0	2.1
Mar. 1	6.2	6.1	-0.1	0.0	1.9	2.0	0.1	2.0	2.1
Jun. 1	4.1	4.1	0.0	0.0	2.0	2.0	0.0	2.0	2.1
Sep. 1	2.1	2.1	0.0	0.0	2.0	2.0	0.0	2.0	2.1

Table 37. Possible Analyst Interpretation of Quarterly NASS Stock Estimates for Corn in the 2009, 2010, and 2012 Marketing Years

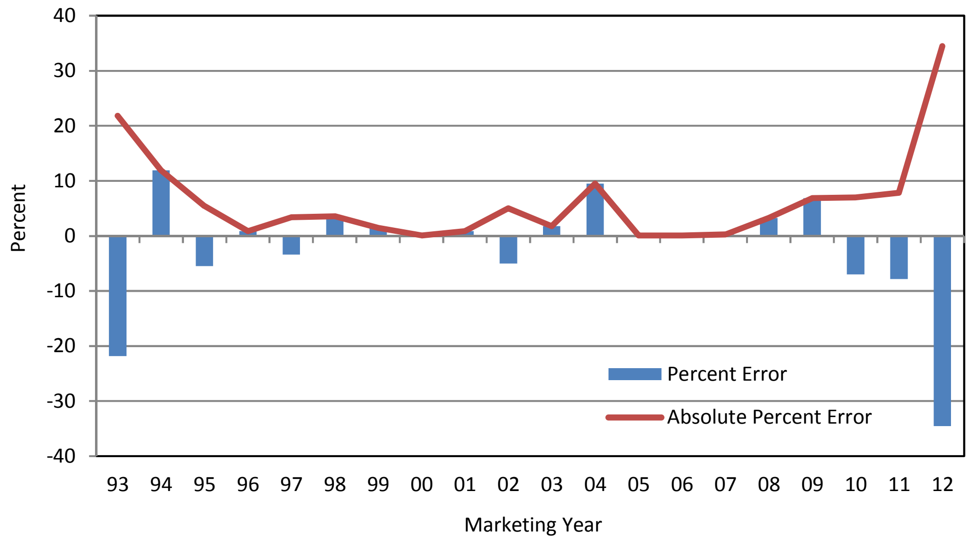
Marketing Year, Quarter	(mil. bu.) Usage Surprise	Analyst Adjustment
2009 Marketing Year		
Sept.-Nov.	89	Raise forecast of Dec.-Feb. usage
Dec.-Feb.	-185	Lower forecast of Mar.-May usage
Mar.-May	303	Raise forecast of Jun.-Aug. usage.
Jun.-Aug.	-301	
2010 Marketing Year		
Sept.-Nov.	13	Unchanged forecast of Dec.-Feb. usage
Dec.-Feb.	178	Raise forecast of Mar.-May usage
Mar.-May	-346	Lower forecast of Jun.-Aug. usage
Jun.-Aug.	-166	
2012 Marketing Year		
Sept.-Nov.	334	Raise forecast of Dec.-Feb. usage
Dec.-Feb.	-386	Lower forecast of Mar.-May usage
Mar.-May	303	Raise forecast of Jun.-Aug. usage
Jun.-Aug.	-143	

Figure 1. WAOB May Yield Forecast Errors, U.S. Corn, 1993-2012 Marketing Years



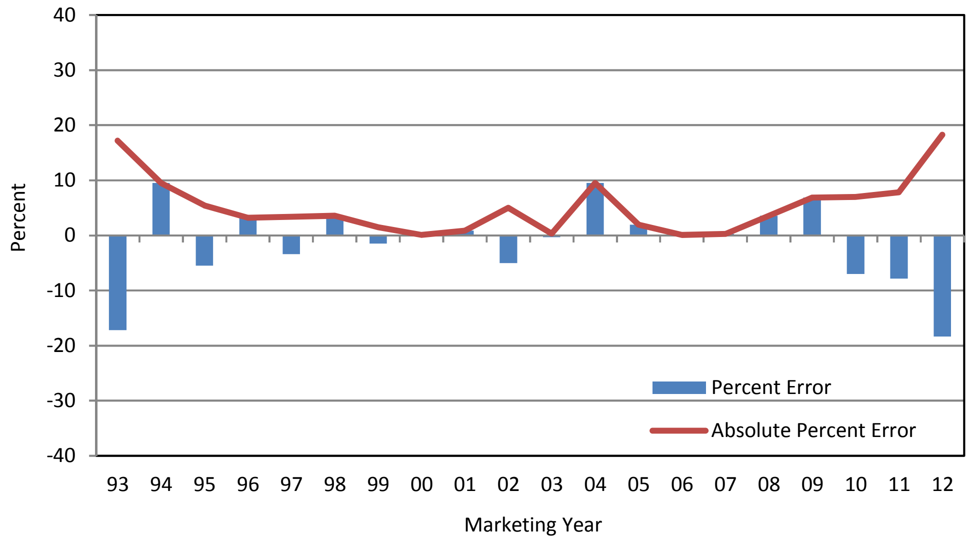
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 2. WAOB June Yield Forecast Errors, U.S. Corn, 1993-2012 Marketing Years



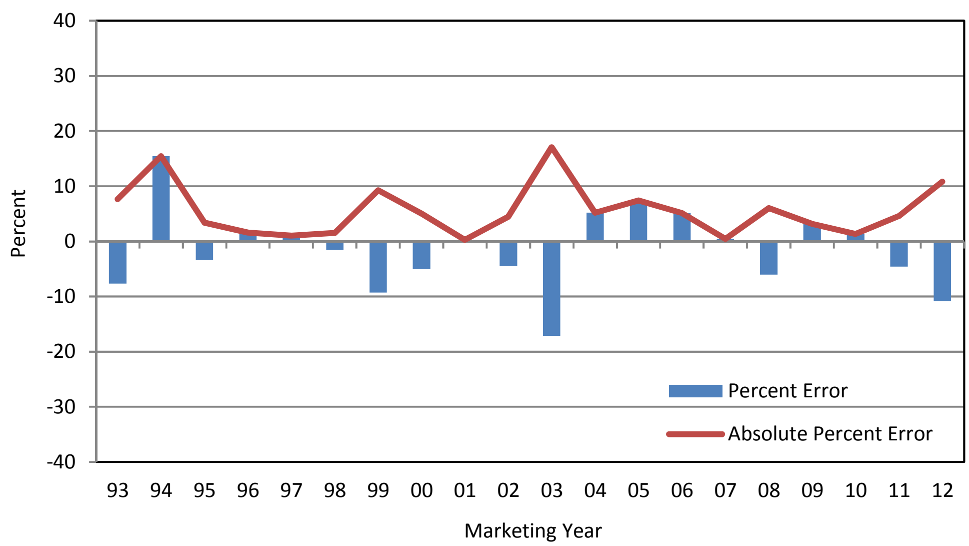
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 3. WAOB July Yield Forecast Errors, U.S. Corn, 1993-2012 Marketing Years



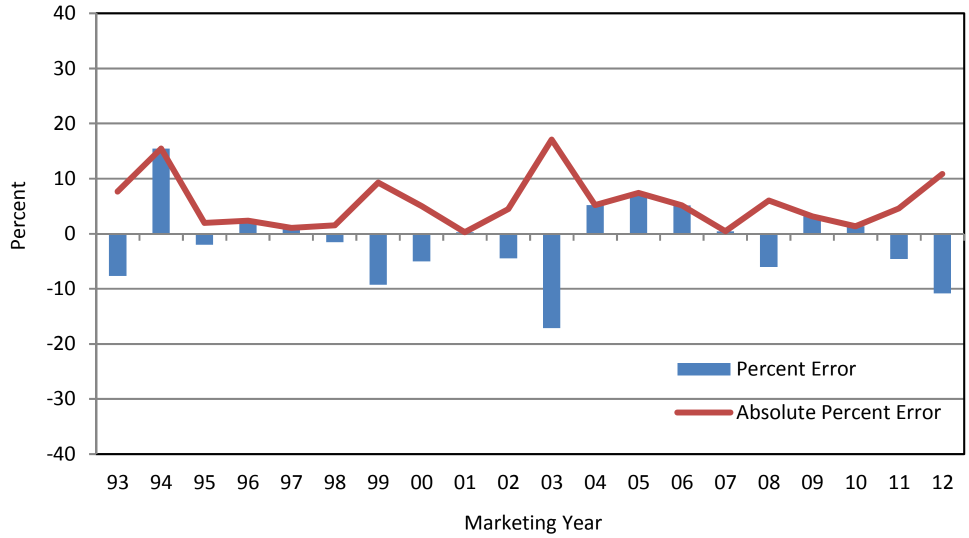
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 4. WAOB May Yield Forecast Errors, U.S. Soybeans, 1993-2012 Marketing Years



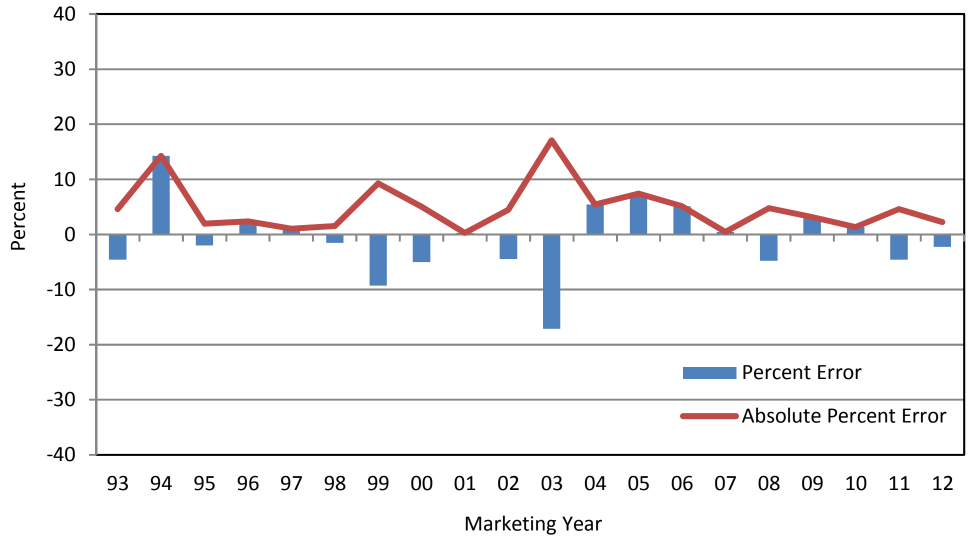
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 5. WAOB June Yield Forecast Errors, U.S. Soybeans, 1993-2012 Marketing Years



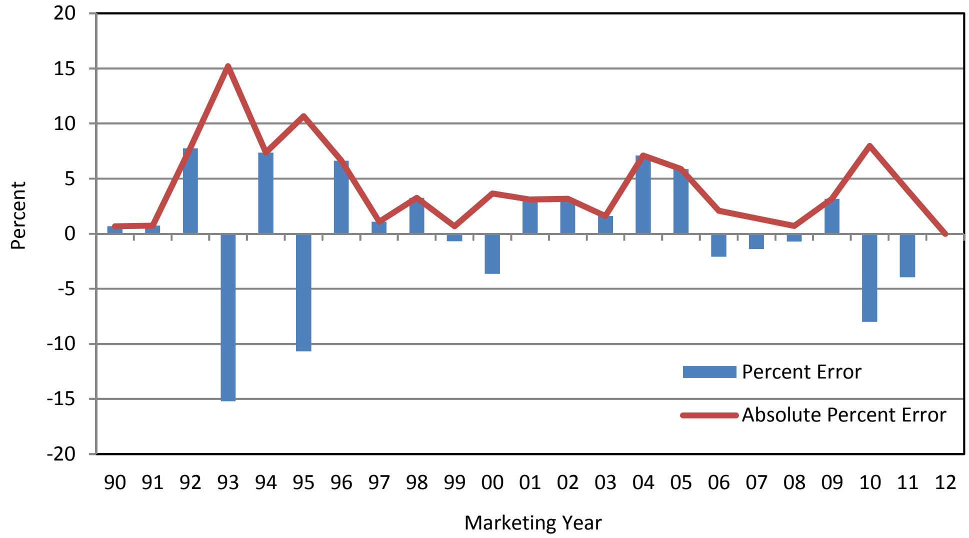
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 6. WAOB July Yield Forecast Errors, U.S. Soybeans, 1993-2012 Marketing Years



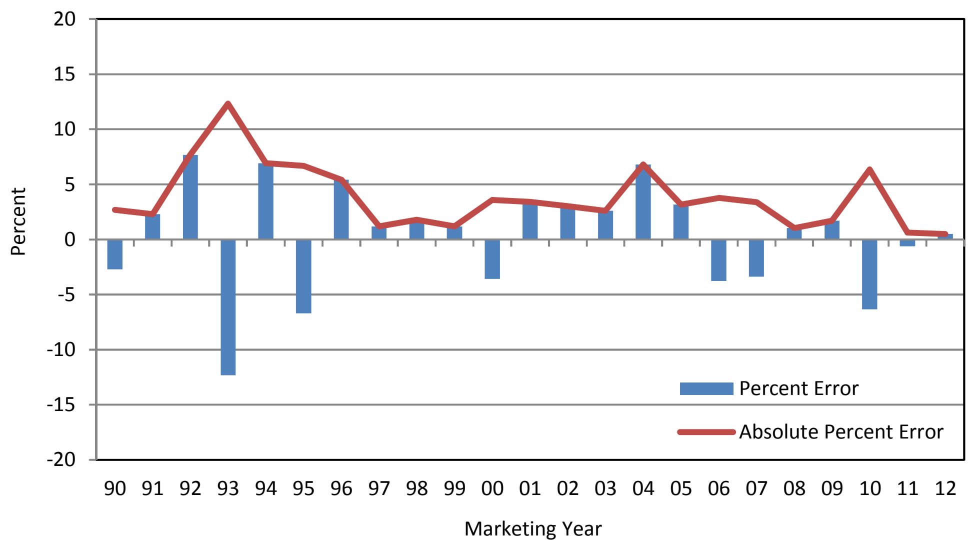
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 7. NASS August Yield Forecast Errors, U.S. Corn, 1990-2012 Marketing Years



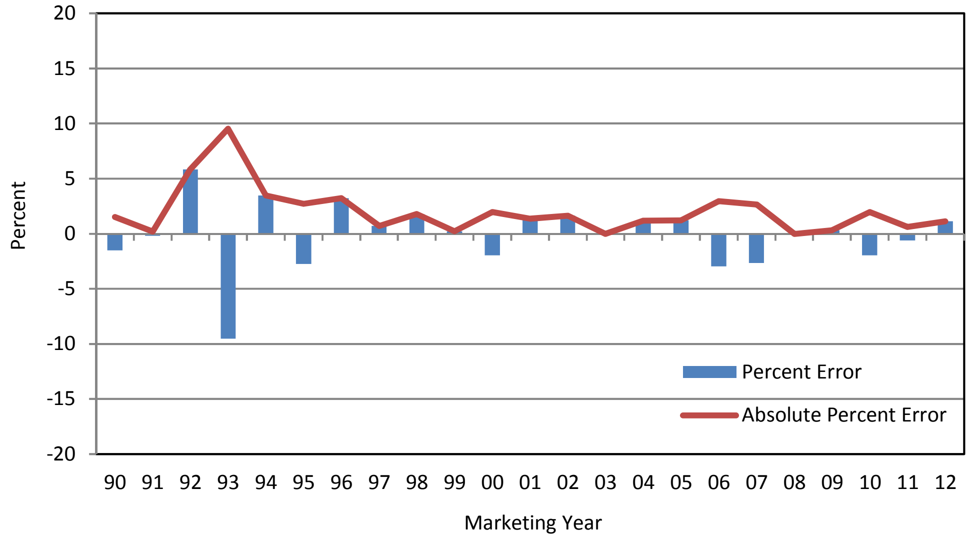
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 8. NASS September Yield Forecast Errors, U.S. Corn, 1990-2012 Marketing Years



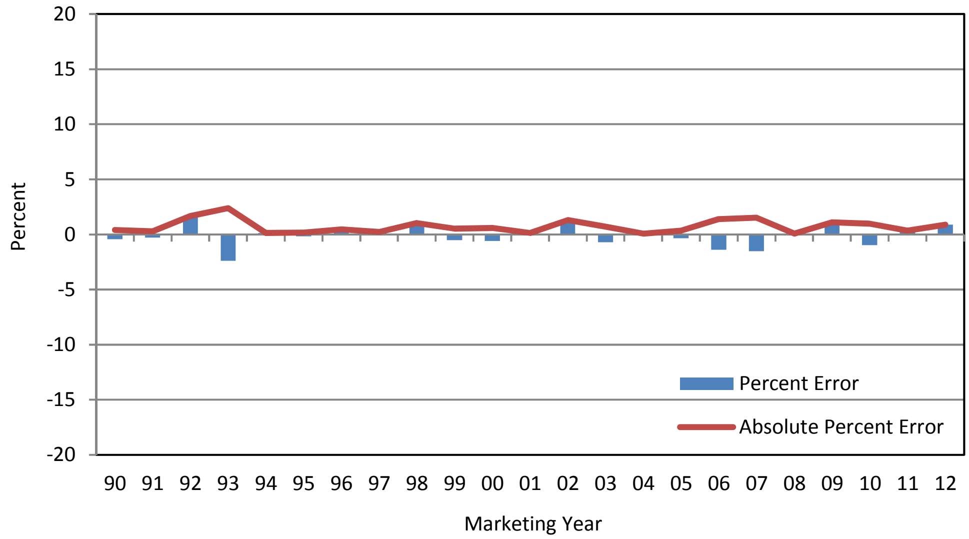
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 9. NASS October Yield Forecast Errors, U.S. Corn, 1990-2012 Marketing Years



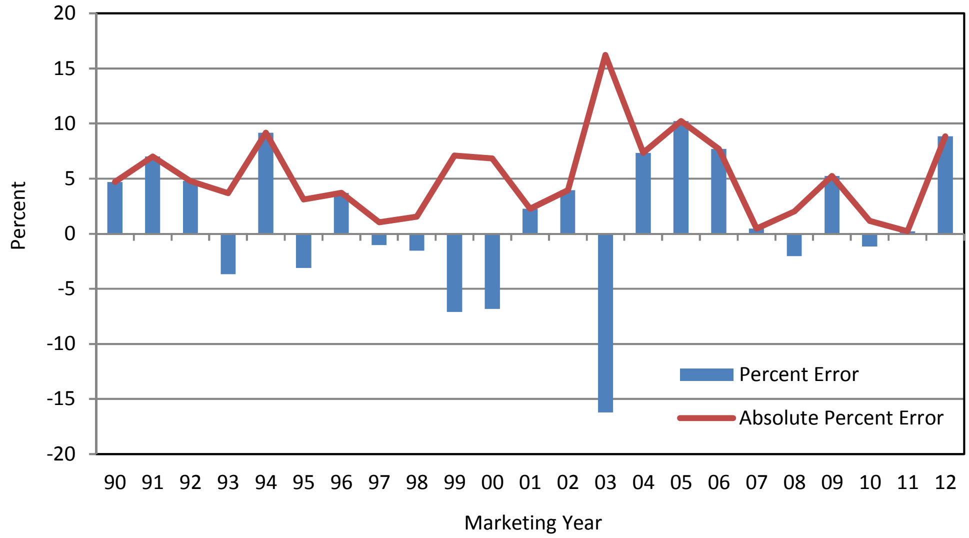
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 10. NASS November Yield Forecast Errors, U.S. Corn, 1990-2012 Marketing Years



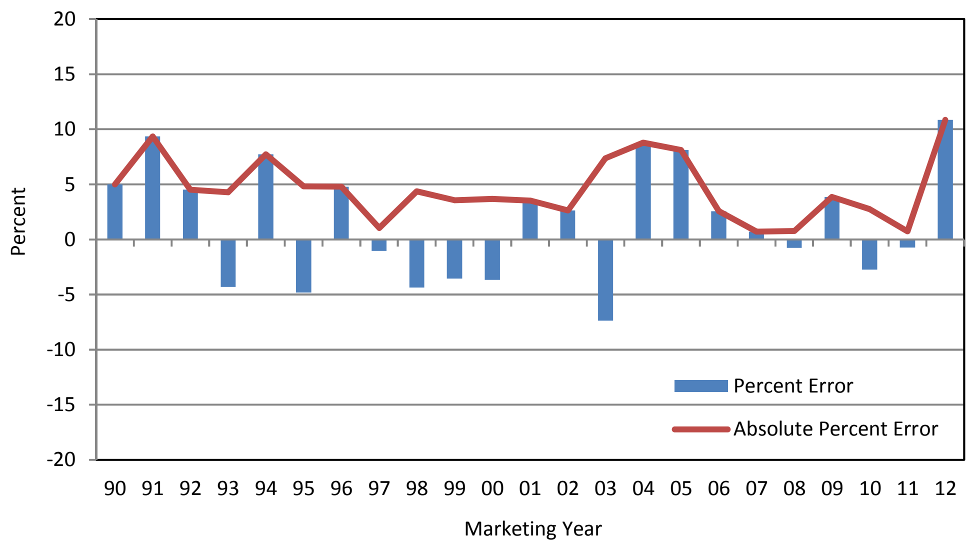
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 11. NASS August Yield Forecast Errors, U.S. Soybeans, 1990-2012 Marketing Years



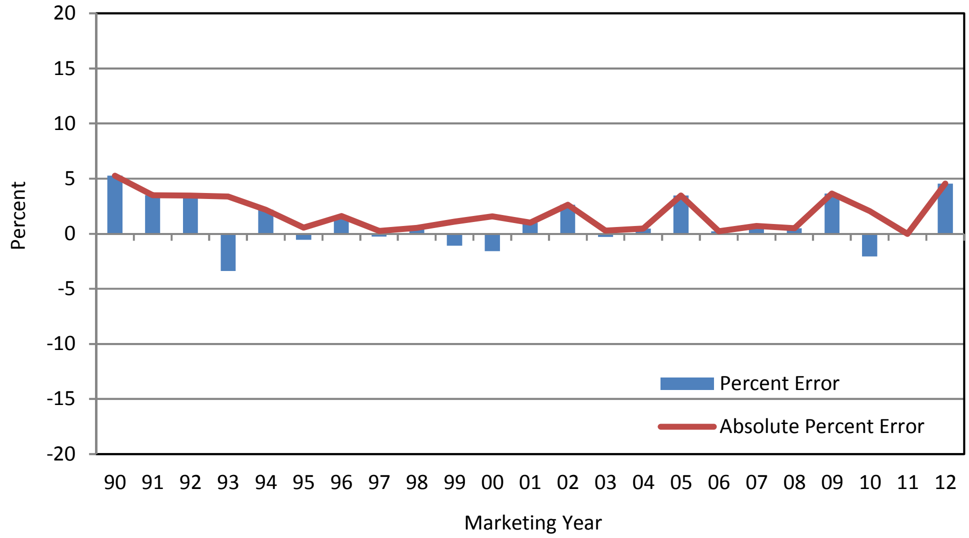
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 12. NASS September Yield Forecast Errors, U.S. Soybeans, 1990-2012 Marketing Years



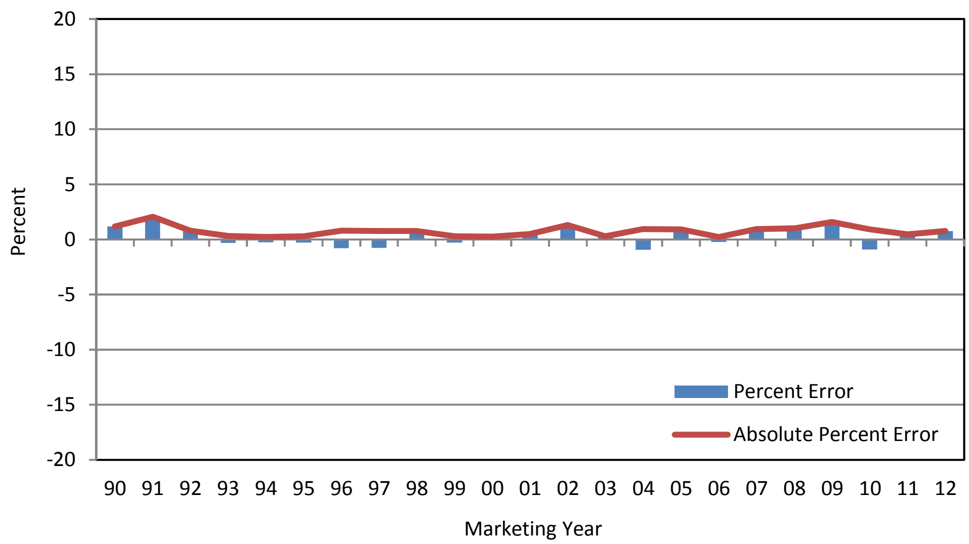
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 13. NASS October Yield Forecast Errors, U.S. Soybeans, 1990-2012 Marketing Years



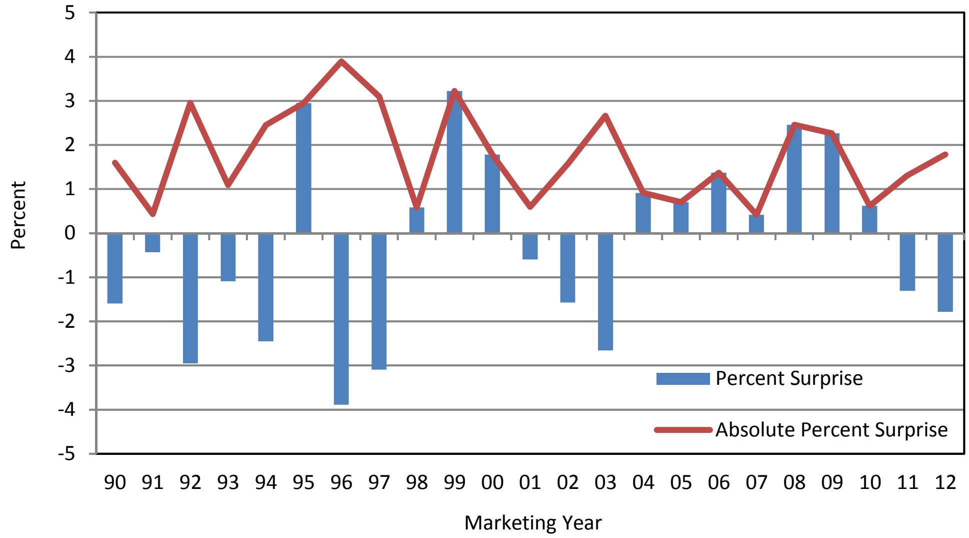
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 14. NASS November Yield Forecast Errors, U.S. Soybeans, 1990-2012 Marketing Years



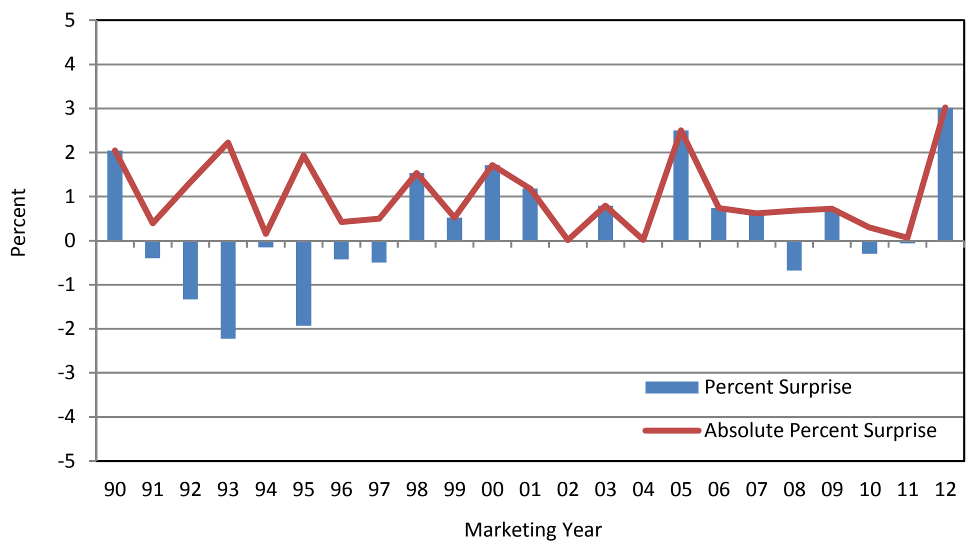
Note: A positive (negative) error occurs when the forecast is lower (higher) than the actual.

Figure 15. Market Surprise for NASS August Production Forecasts, U.S. Corn, 1990-2012 Marketing Years



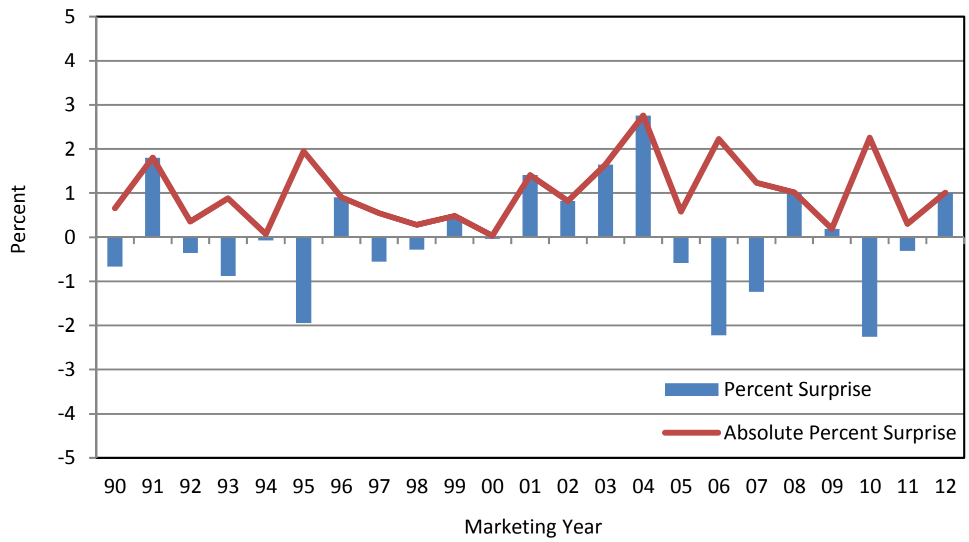
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 16. Market Surprise for NASS September Production Forecasts, U.S. Corn, 1990-2012 Marketing Years



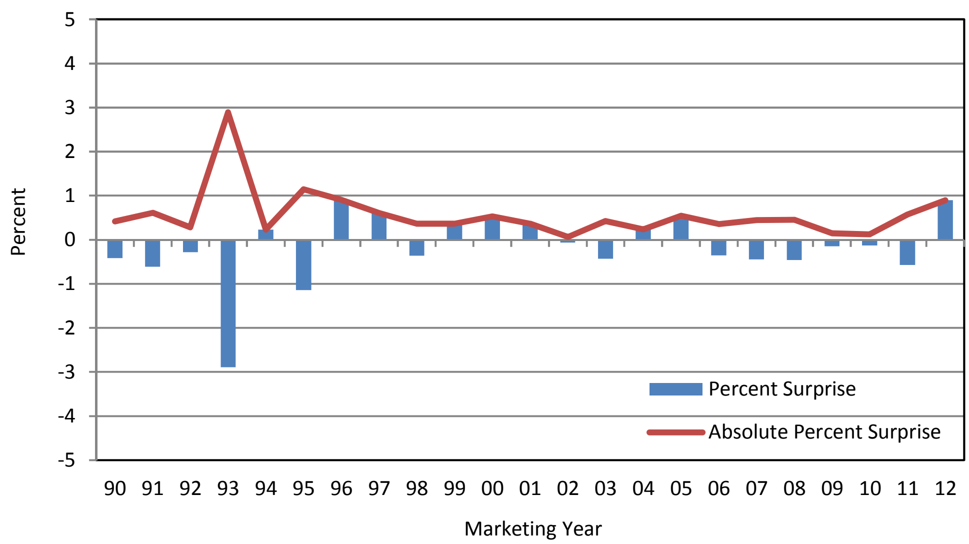
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 17. Market Surprise for NASS October Production Forecasts, U.S. Corn, 1990-2012 Marketing Years



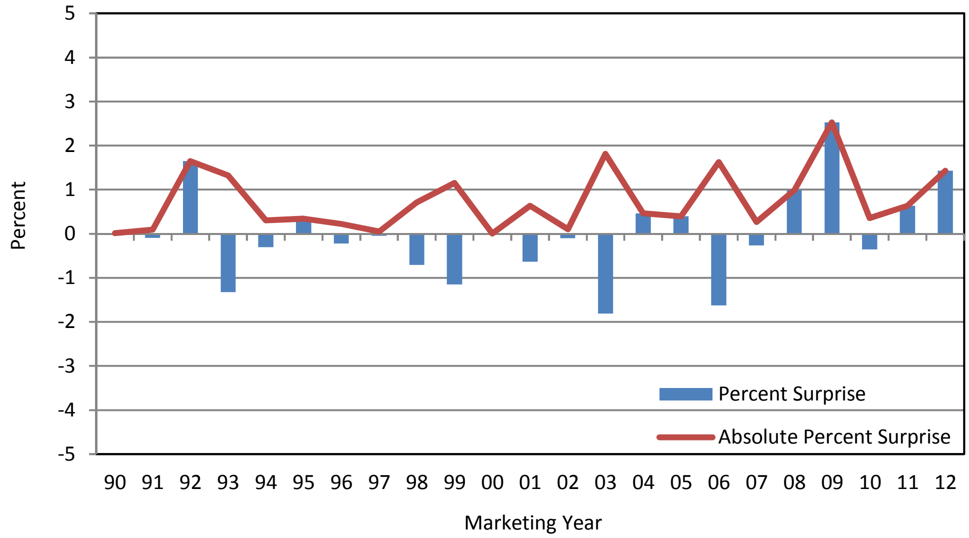
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 18. Market Surprise for NASS November Production Forecasts, U.S. Corn, 1990-2012 Marketing Years



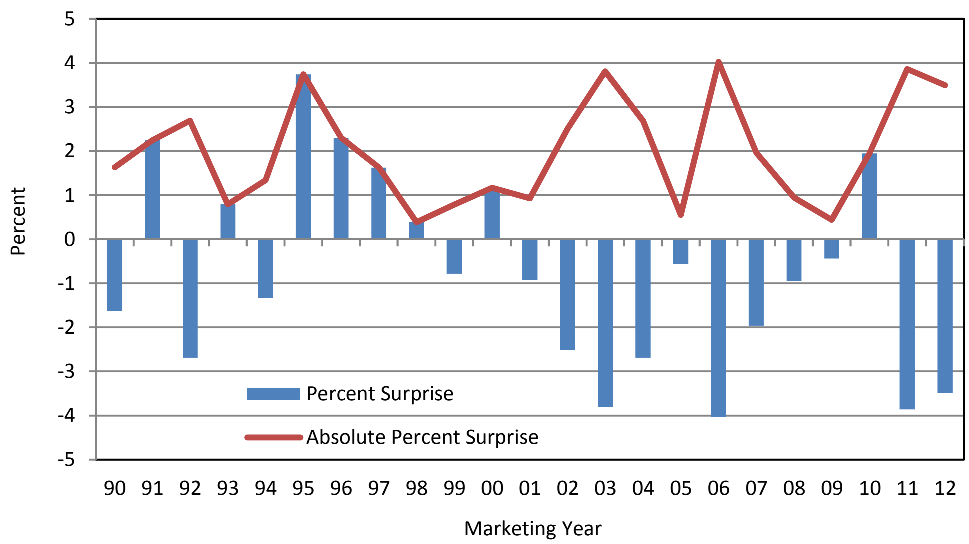
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 19. Market Surprise for NASS January Production Estimates, U.S. Corn, 1990-2012 Marketing Years



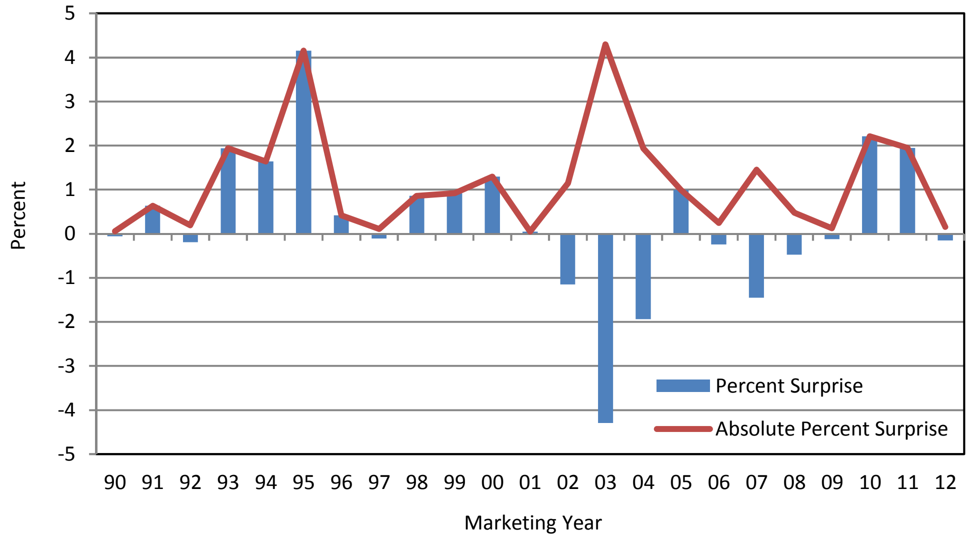
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 20. Market Surprise for NASS August Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years



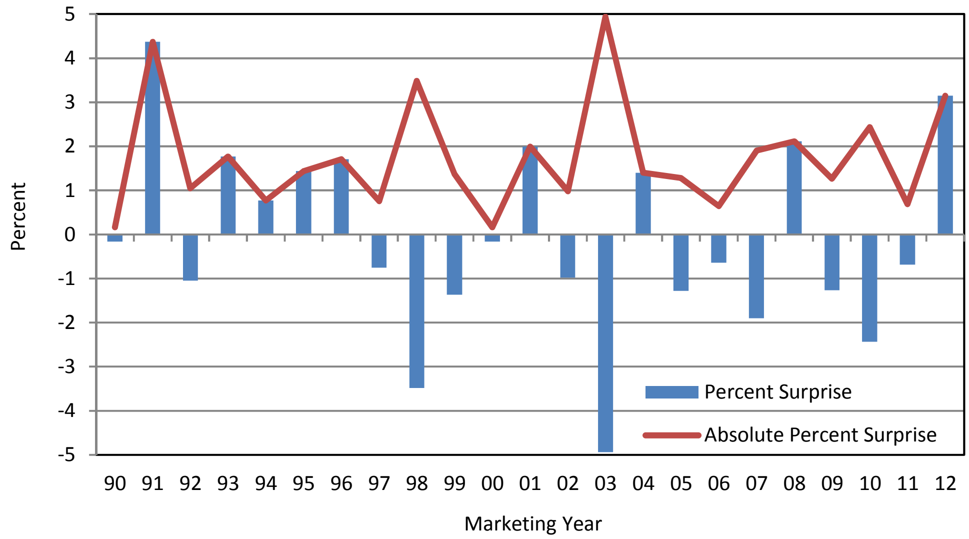
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 21. Market Surprise for NASS September Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years



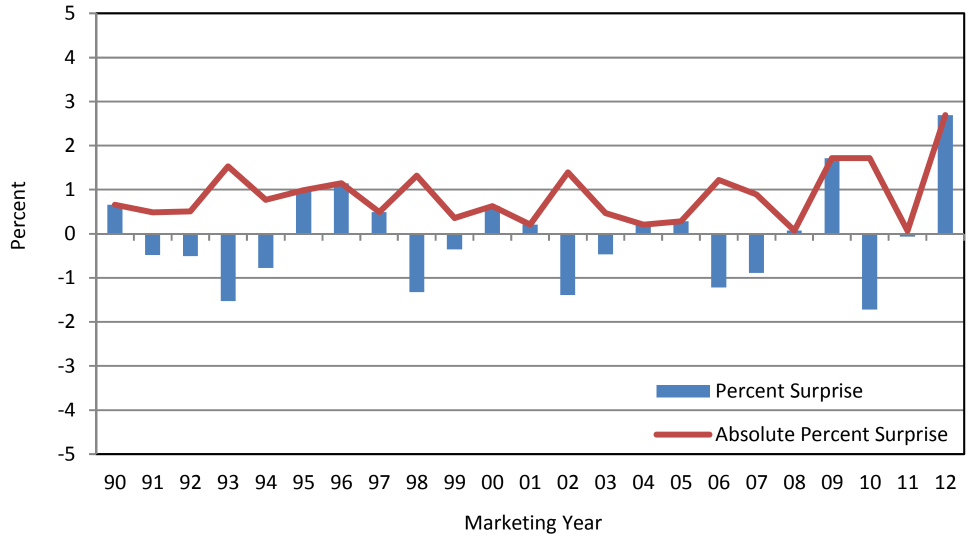
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 22. Market Surprise for NASS October Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years



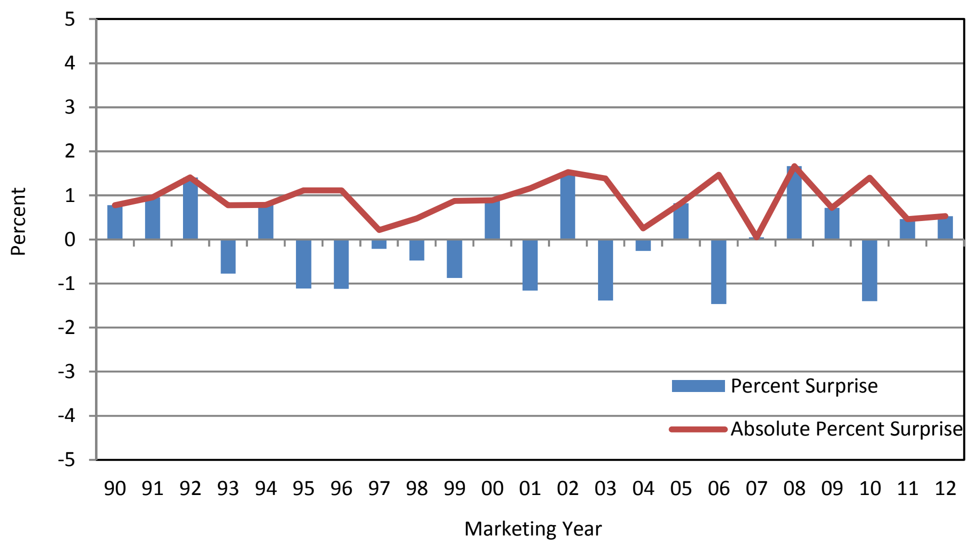
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 23. Market Surprise for NASS November Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years



Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 24. Market Surprise for NASS January Production Estimate, U.S. Soybeans, 1990-2012 Marketing Years



Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 25. Difference in NASS and Market Analyst Absolute Percent Error for August Production Forecasts, U.S. Corn, 1990-2012 Marketing Years

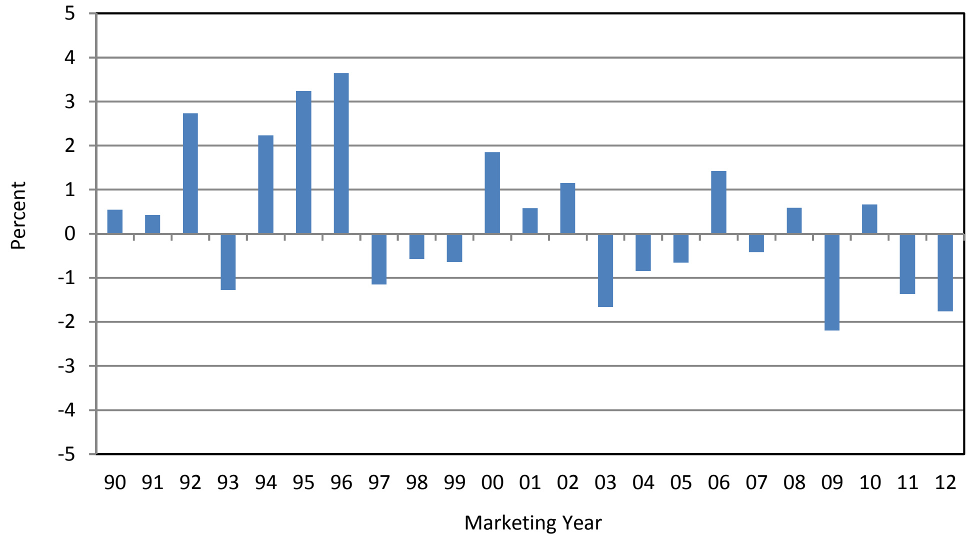


Figure 26. Difference in NASS and Market Analyst Absolute Percent Error for September Production Forecasts, U.S. Corn, 1990-2012 Marketing Years

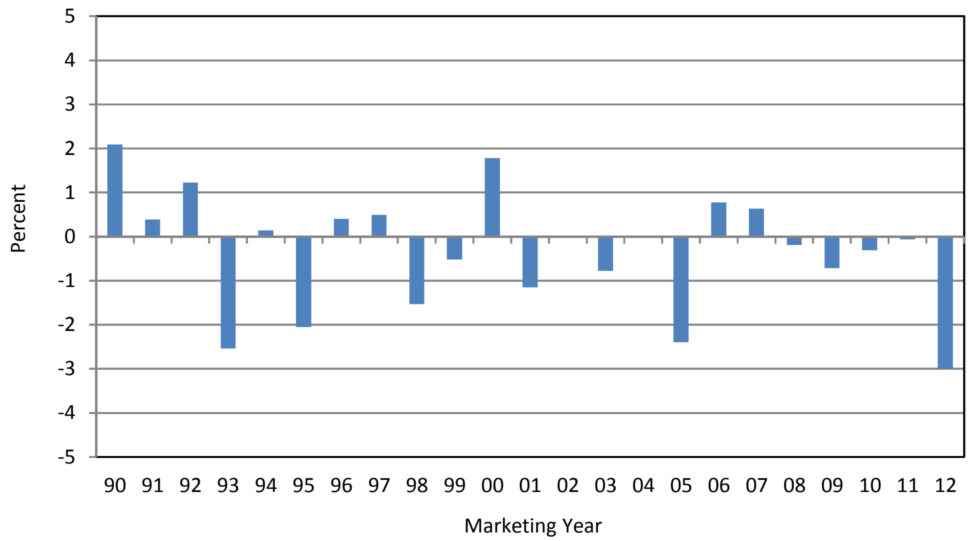


Figure 27. Difference in NASS and Market Analyst Absolute Percent Error for October Production Forecasts, U.S. Corn, 1990-2012 Marketing Years

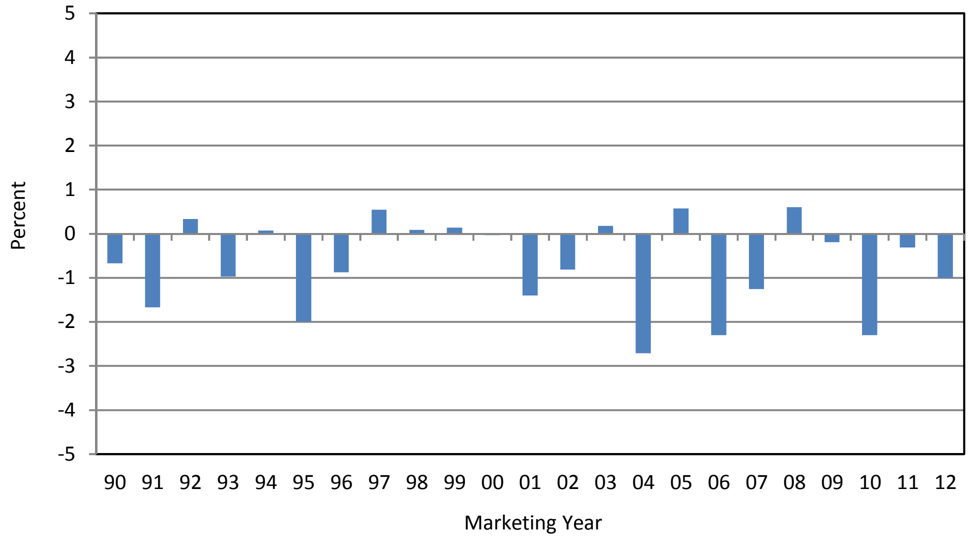


Figure 28. Difference in NASS and Market Analyst Absolute Percent Error for November Production Forecasts, U.S. Corn, 1990-2012 Marketing Years

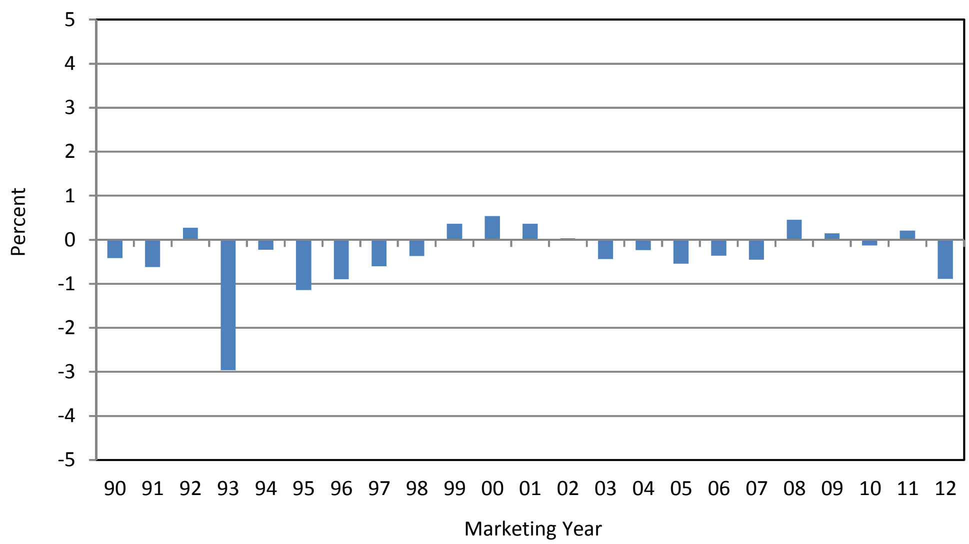


Figure 29. Difference in NASS and Market Analyst Absolute Percent Error for August Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

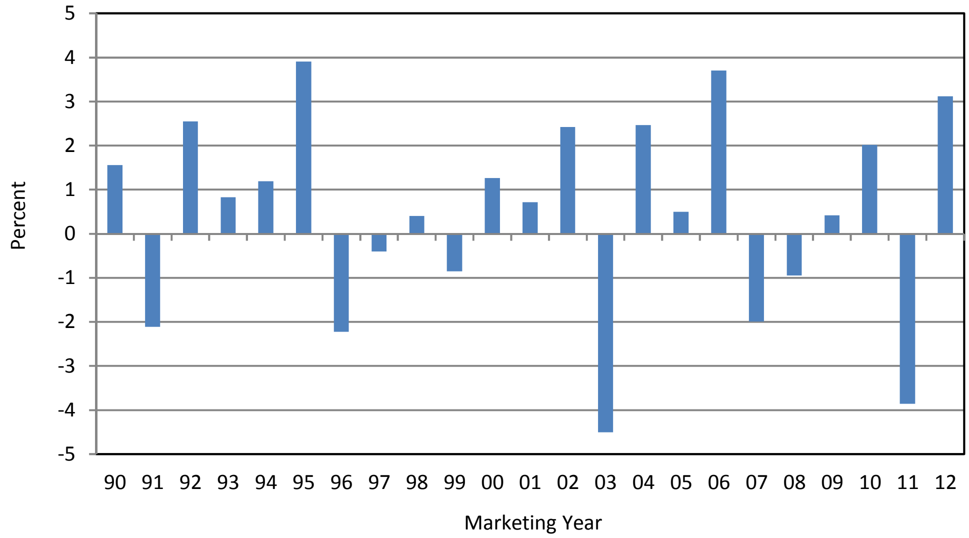


Figure 30. Difference in NASS and Market Analyst Absolute Percent Error for September Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

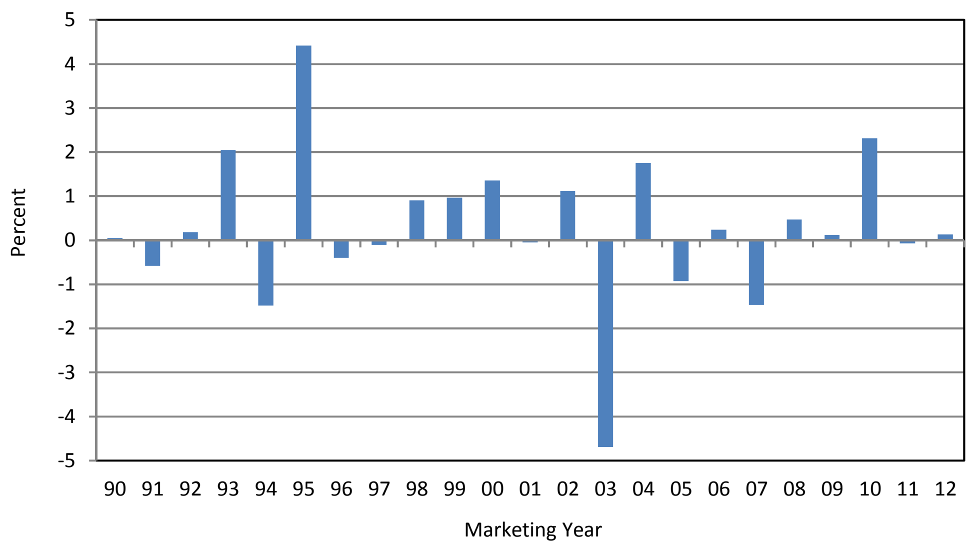


Figure 31. Difference in NASS and Market Analyst Absolute Percent Error for October Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

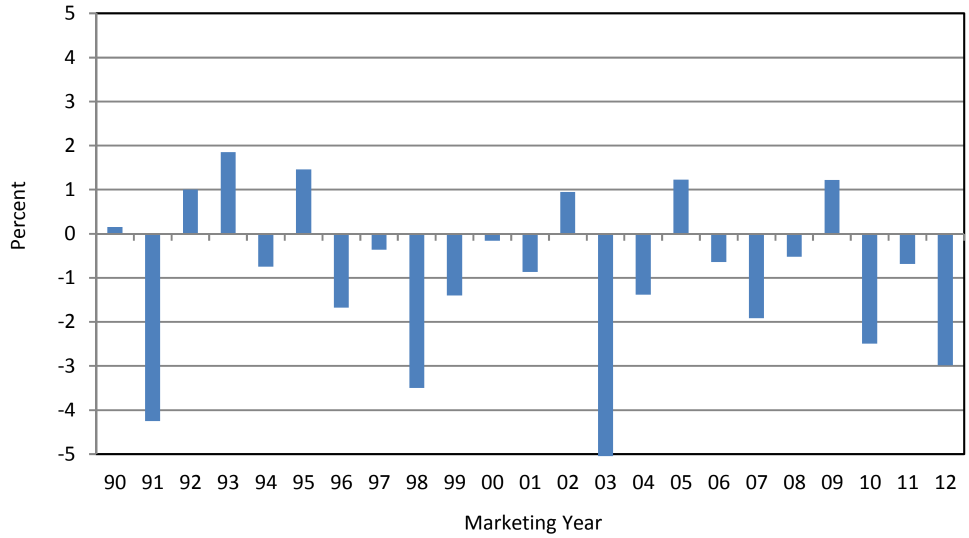


Figure 32. Difference in NASS and Market Analyst Absolute Percent Error for November Production Forecasts, U.S. Soybeans, 1990-2012 Marketing Years

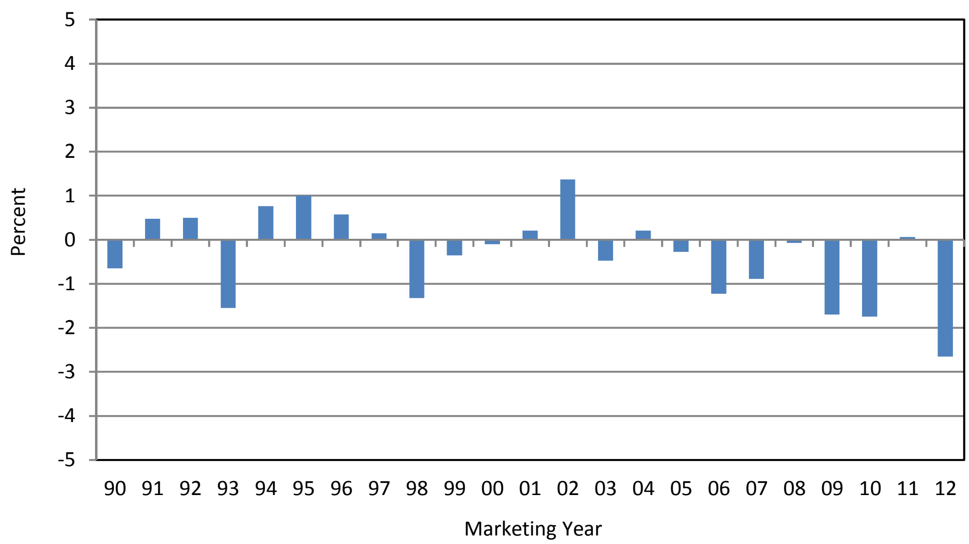
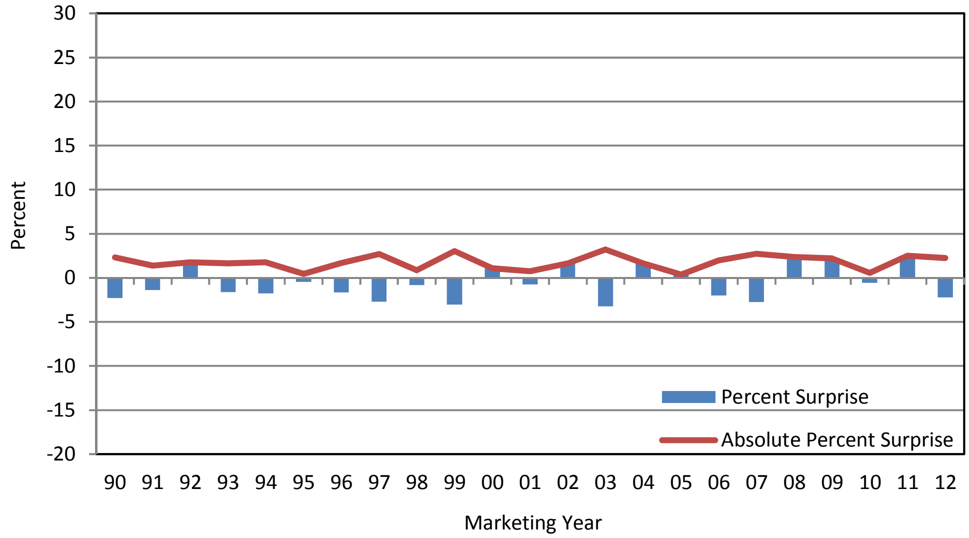
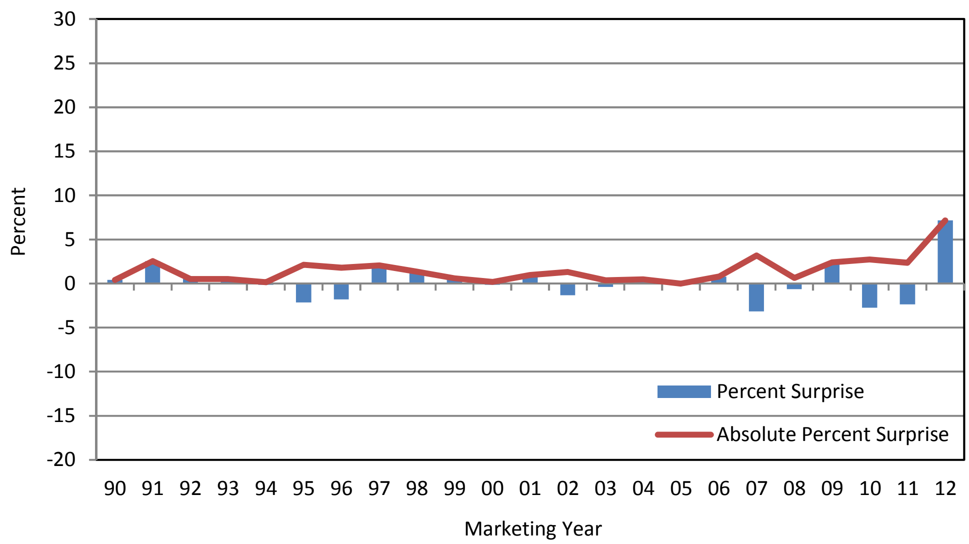


Figure 33. Market Surprise for NASS December 1 Stocks Estimates, U.S. Corn, 1990-2012 Marketing Years



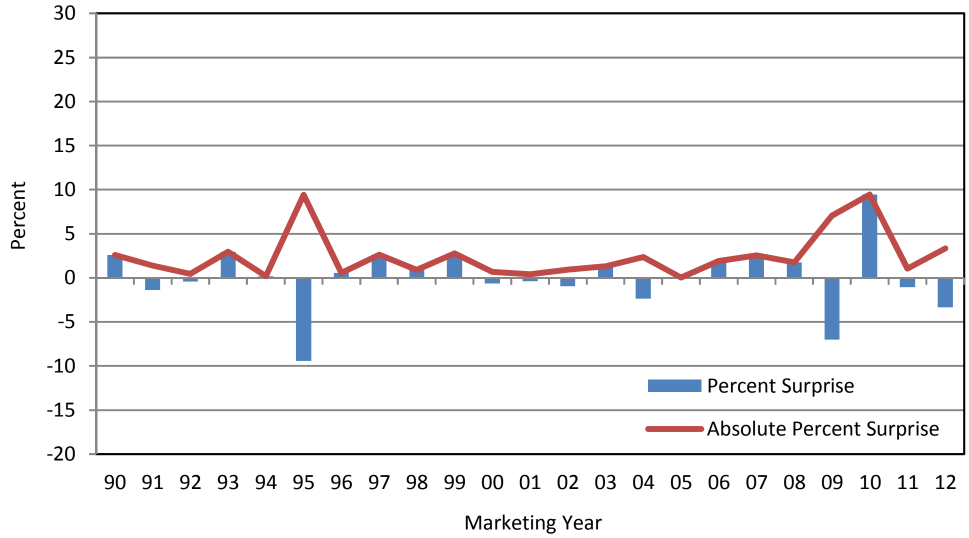
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 34. Market Surprise for NASS March 1 Stocks Estimates, U.S. Corn, 1990-2012 Marketing Years



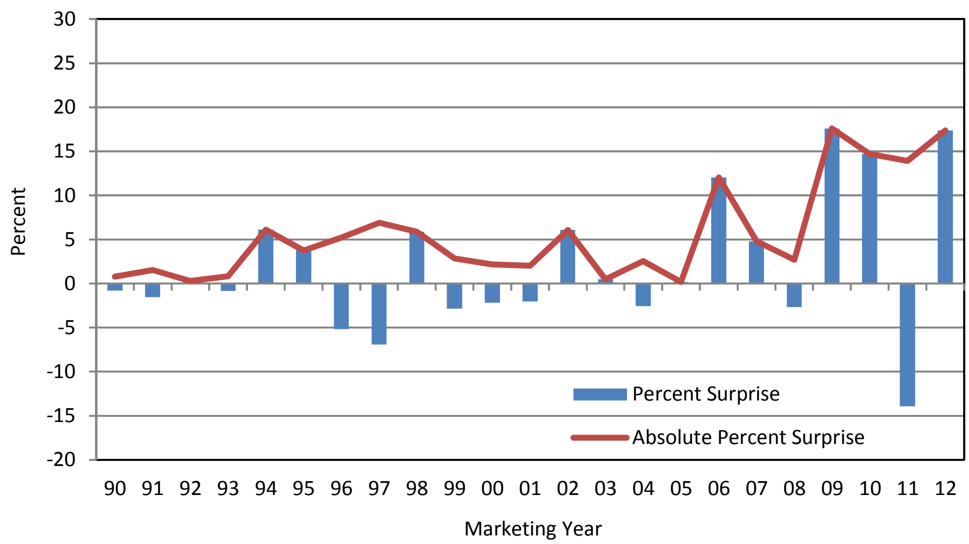
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 35. Market Surprise for NASS June 1 Stocks Estimates, U.S. Corn, 1990-2012 Marketing Years



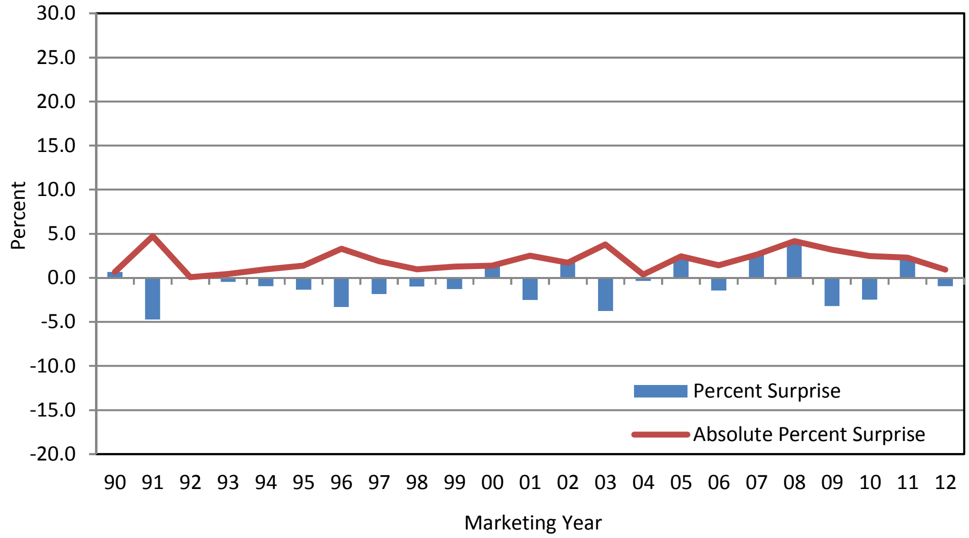
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 36. Market Surprise for NASS September 1 Stocks Estimates, U.S. Corn, 1990-2012 Marketing Years



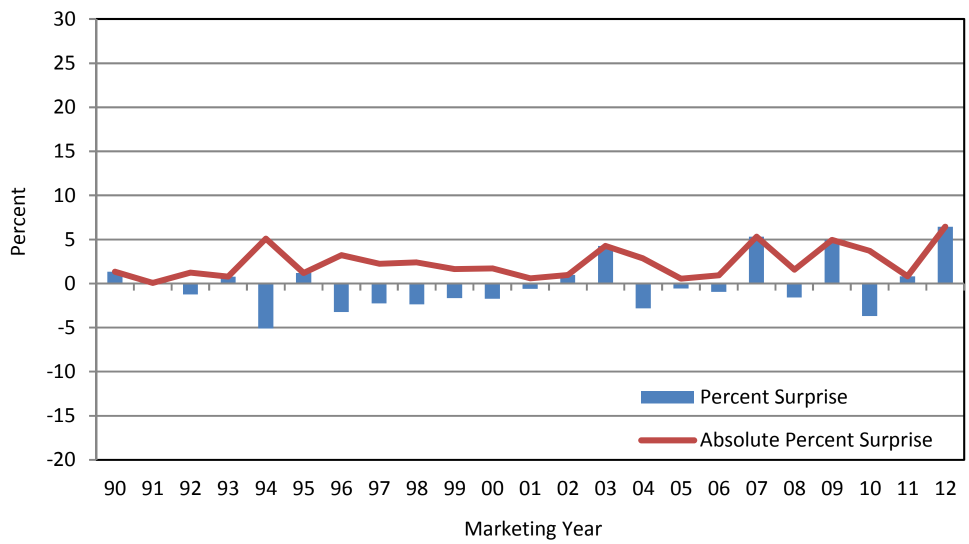
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 37. Market Surprise for NASS December 1 Stocks Estimates, U.S. Soybeans, 1990-2012 Marketing Years



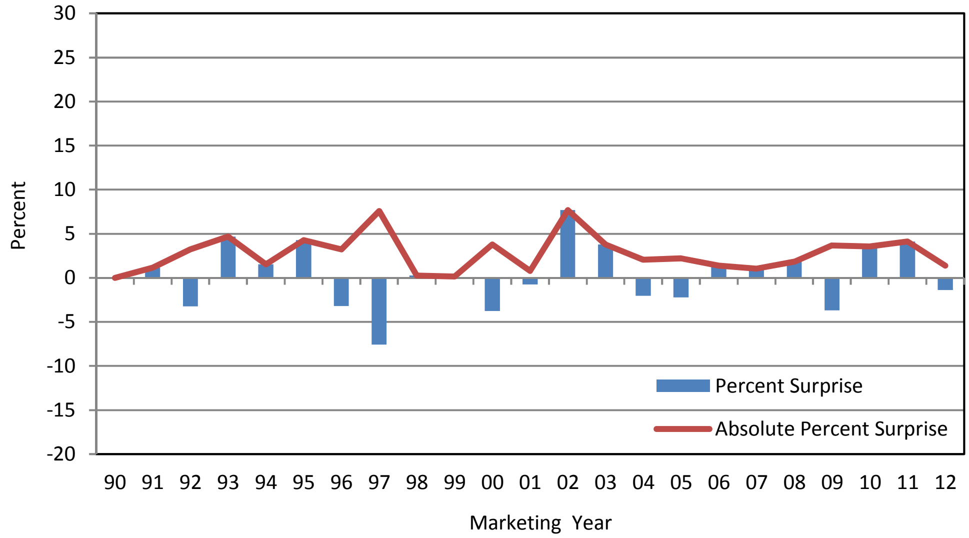
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 38. Market Surprise for NASS March 1 Stocks Estimates, U.S. Soybeans, 1990-2012 Marketing Years



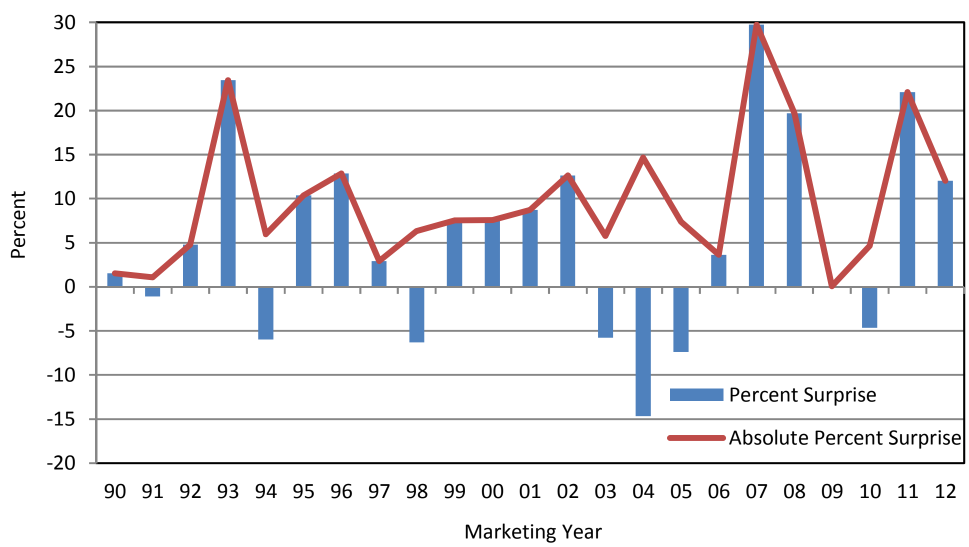
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 39. Market Surprise for NASS June 1 Stocks Estimates, U.S. Soybeans, 1990-2012 Marketing Years



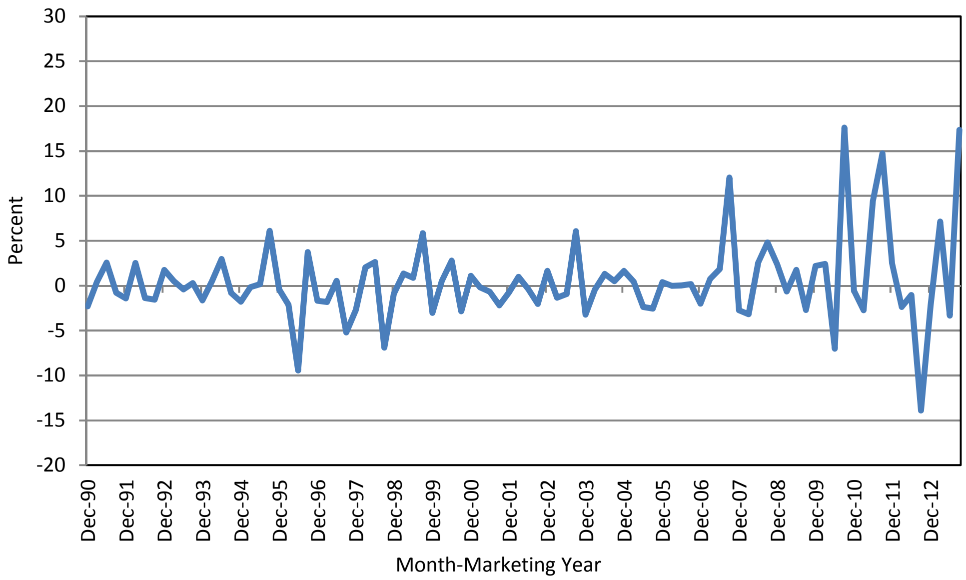
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 40. Market Surprise for NASS September 1 Stocks Estimates, U.S. Soybeans, 1990-2012 Marketing Years



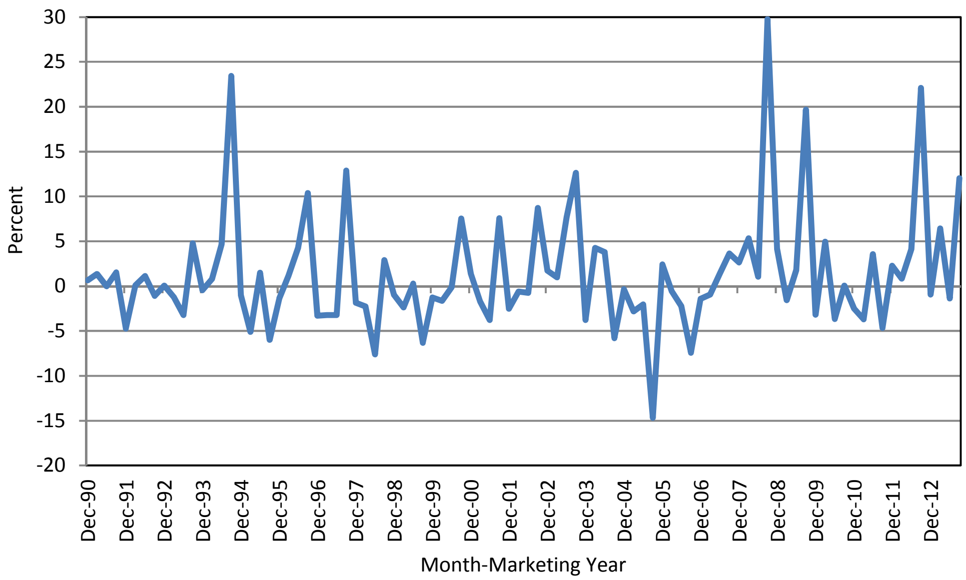
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 41. Market Surprise for All NASS Stocks Estimates, U.S. Corn, 1990-2012 Marketing Years



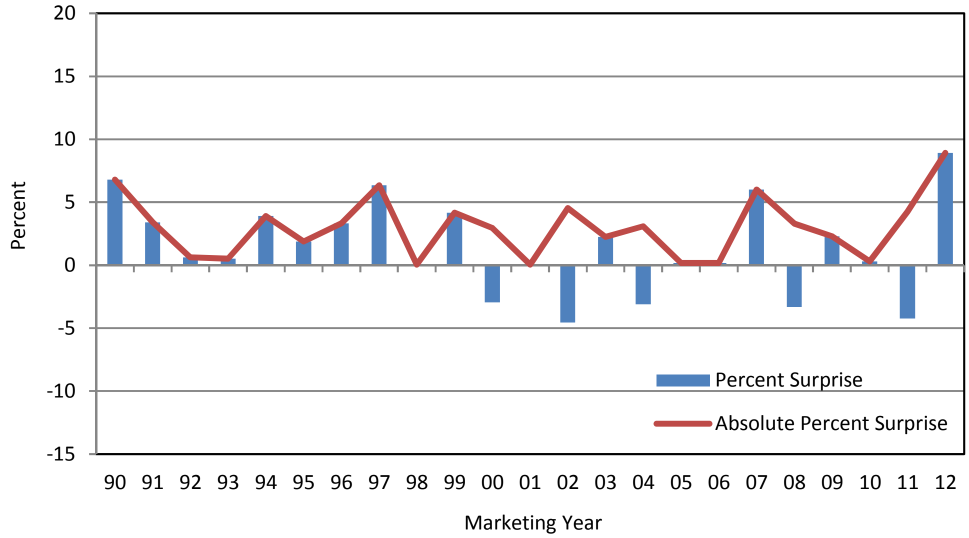
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 42. Market Surprise for All NASS Stocks Estimates, U.S. Soybeans, 1990-2012 Marketing Years



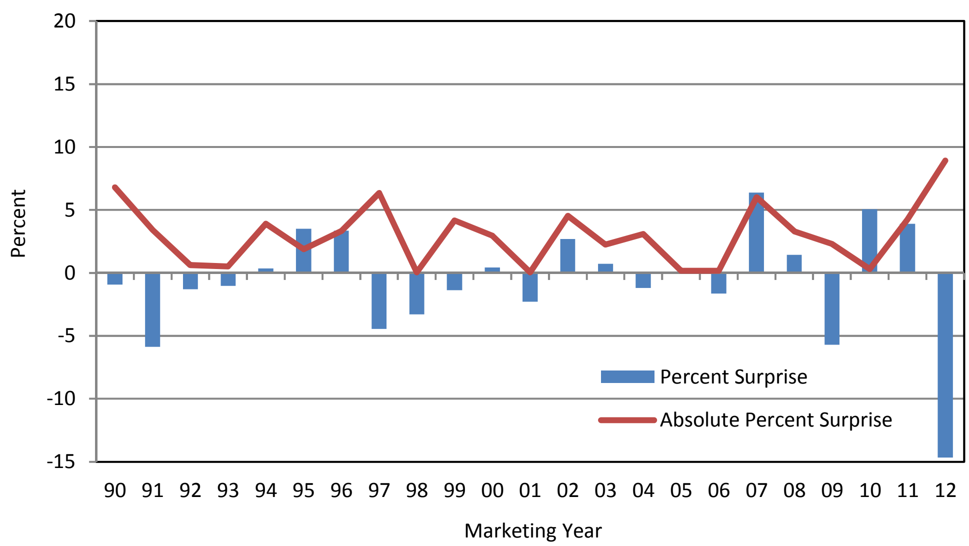
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 43. Market Surprise for NASS September-November Implied Usage Estimates, U.S. Corn, 1990-2012 Marketing Years



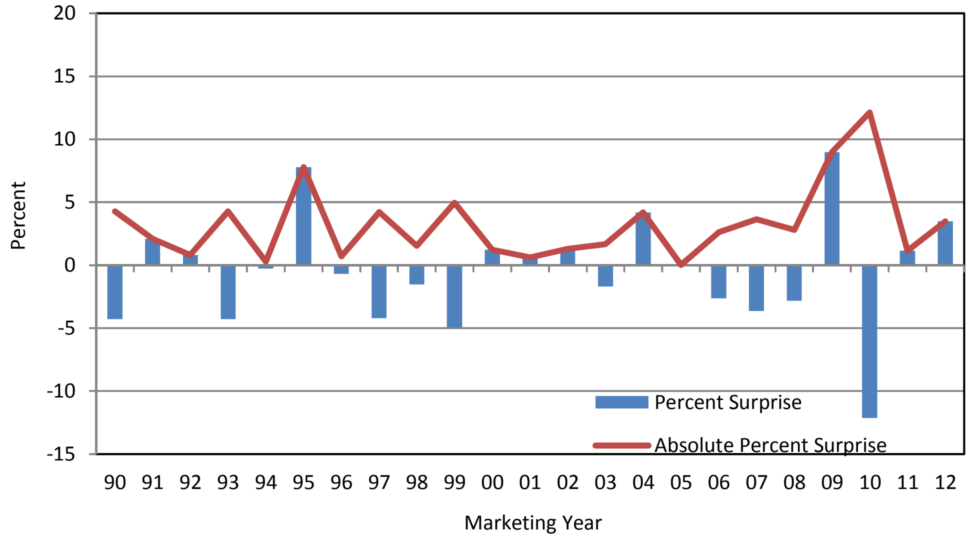
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 44. Market Surprise for NASS December-February Implied Usage Estimates, U.S. Corn, 1990-2012 Marketing Years



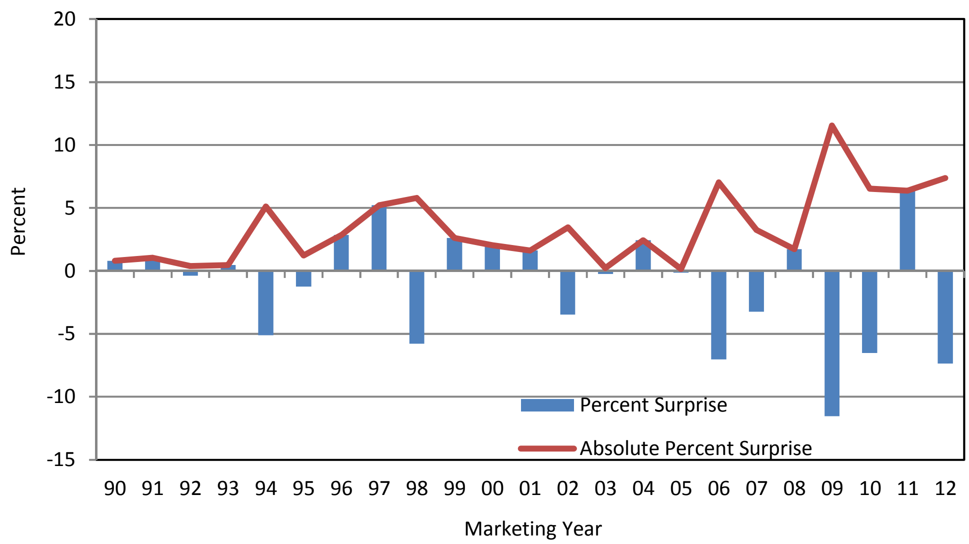
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 45. Market Surprise for NASS March-May Implied Usage Estimates, U.S. Corn, 1990-2012 Marketing Years



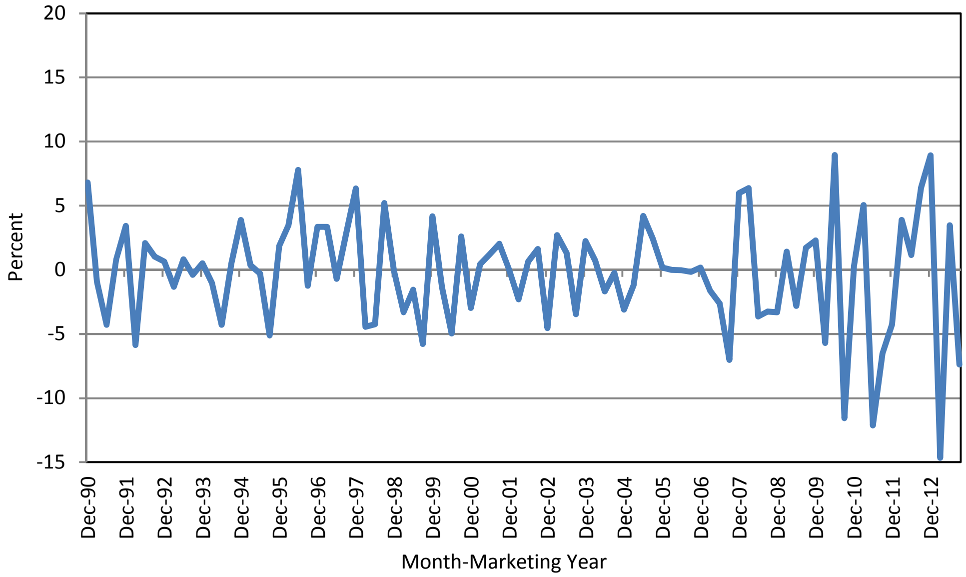
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 46. Market Surprise for NASS June-August Implied Usage Estimates, U.S. Corn, 1990-2012 Marketing Years



Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 47. Market Surprise for NASS Quarterly Implied Usage Estimates, U.S. Corn, 1990-2012 Marketing Years



Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 48. Correlation of Market Surprises for NASS Implied Usage Estimates, U.S. Corn, 2006-2012 Marketing Years

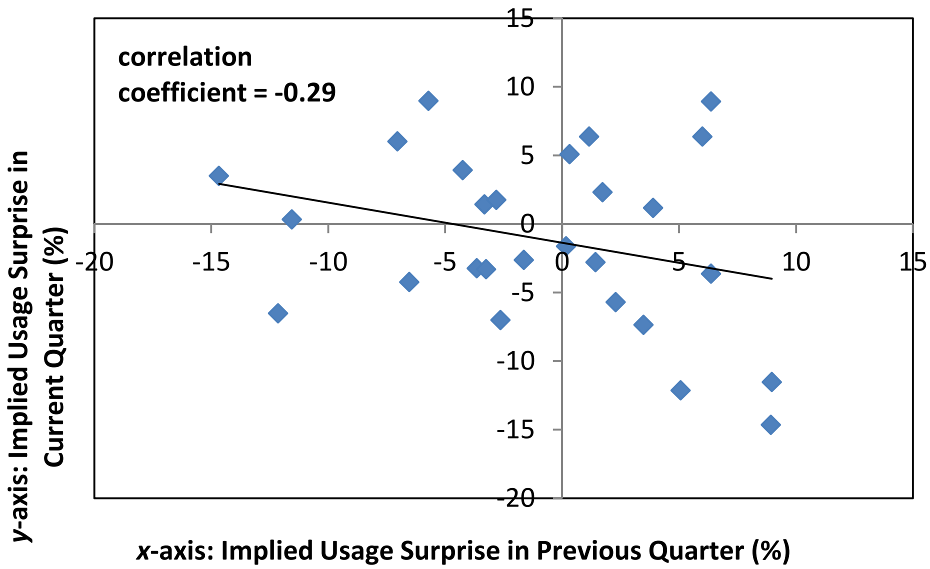
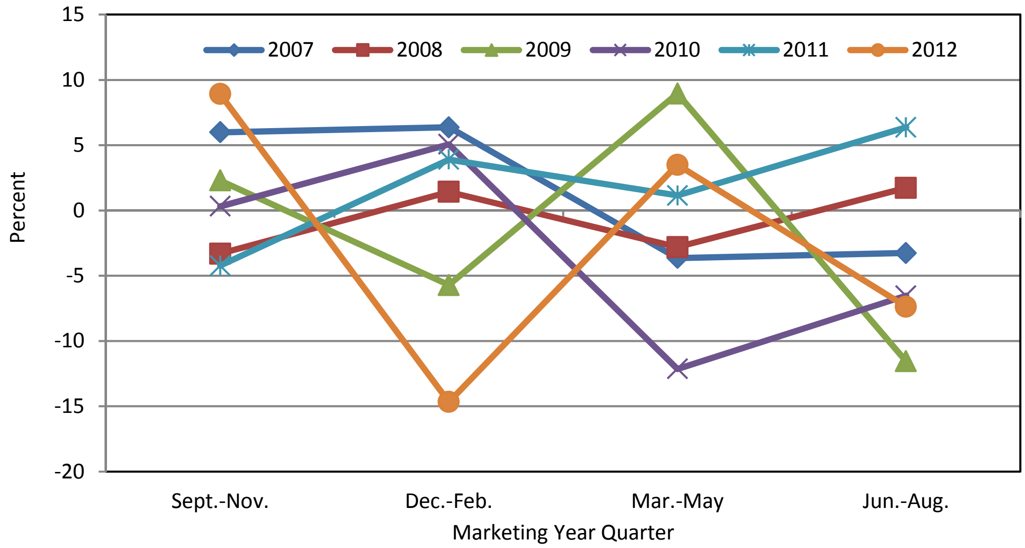
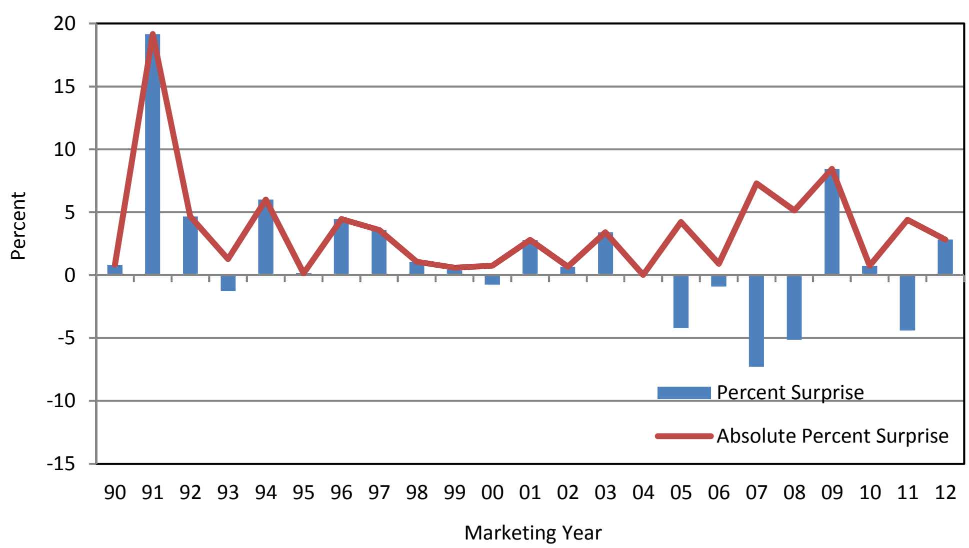


Figure 49. Market Surprise for NASS Quarterly Implied Usage Estimates by Marketing Year, U.S. Corn, 2007-2012 Marketing Years



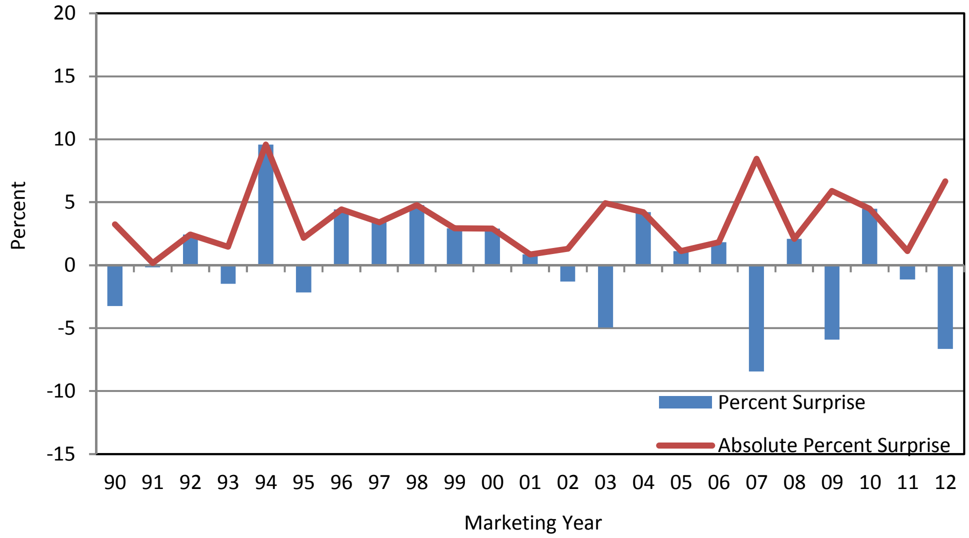
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 50. Market Surprise for NASS September-November Implied Usage Estimates, U.S. Soybeans, 1990-2012 Marketing Years



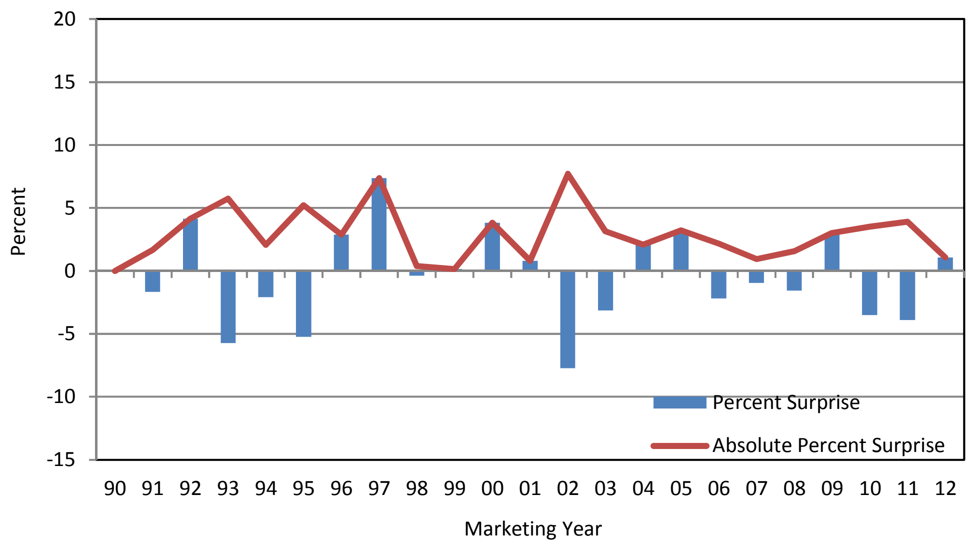
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 51. Market Surprise for NASS December-February Implied Usage Estimates, U.S. Soybeans, 1990-2012 Marketing Years



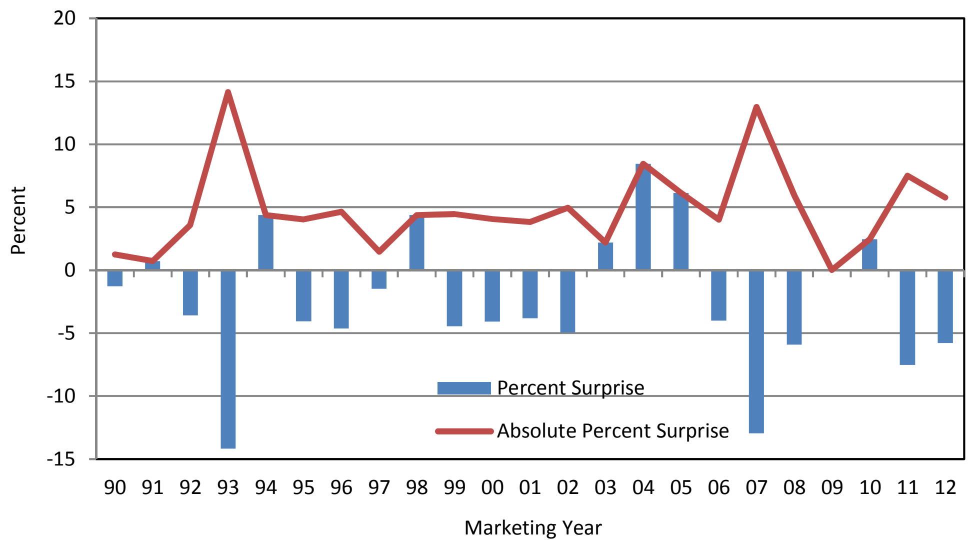
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 52. Market Surprise for NASS March-May Implied Usage Estimates, U.S. Soybeans, 1990-2012 Marketing Years



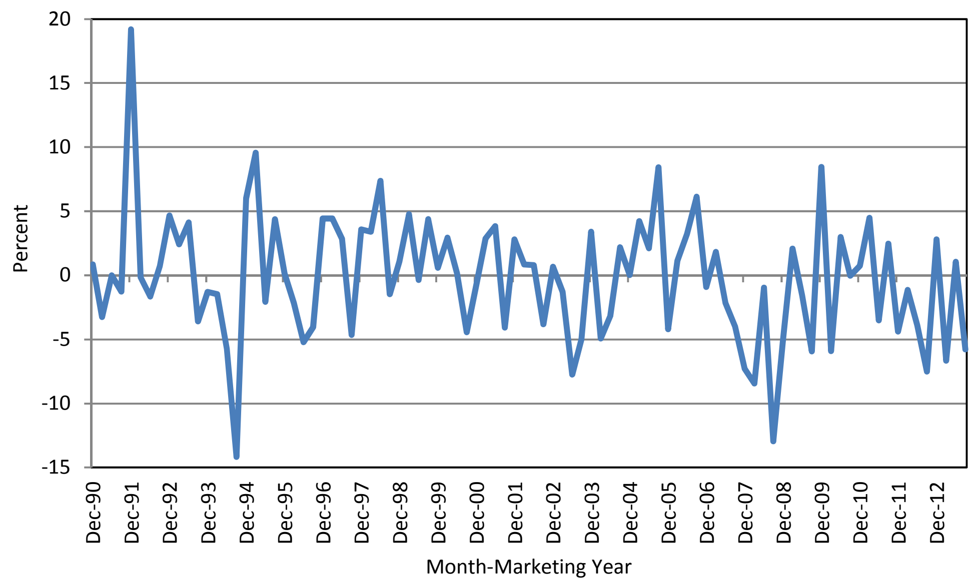
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 53. Market Surprise for NASS June-August Implied Usage Estimates, U.S. Soybeans, 1990-2012 Marketing Years



Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 54. Market Surprise for NASS Quarterly Implied Usage Estimates, U.S. Soybeans, 1990-2012 Marketing Years



Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 55. Correlation of Market Surprises for NASS Implied Usage Estimates, U.S. Soybeans, 2006-2012 Marketing Years

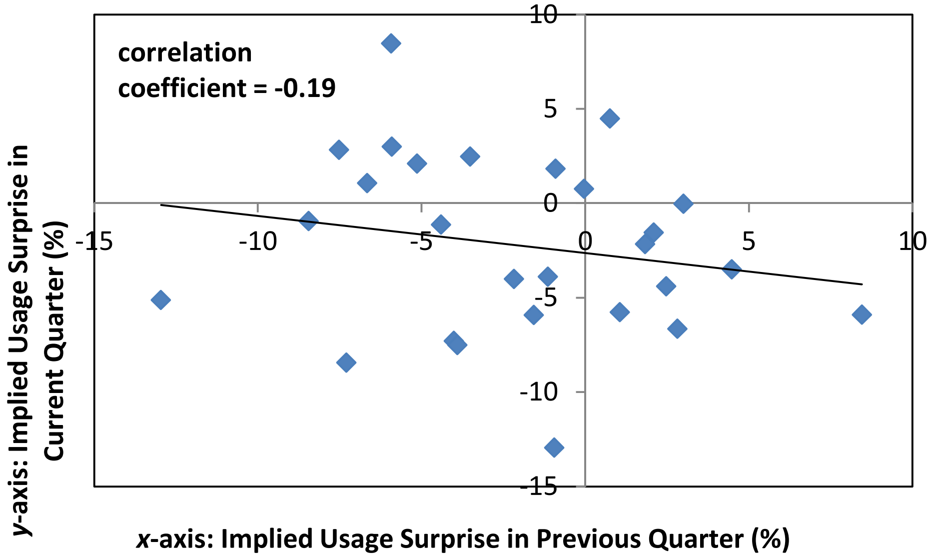
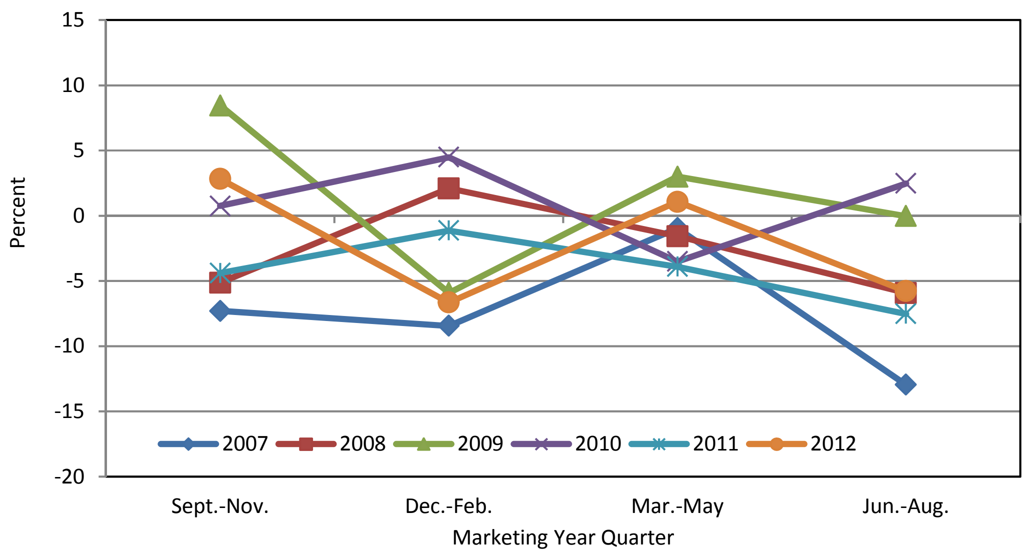


Figure 56. Market Surprise for NASS Quarterly Implied Usage Estimates by Marketing Year, U.S. Soybeans, 2007-2012 Marketing Years



Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 57. Estimated September-November Feed and Residual Usage, U.S. Corn, 1990-2012 Marketing Years

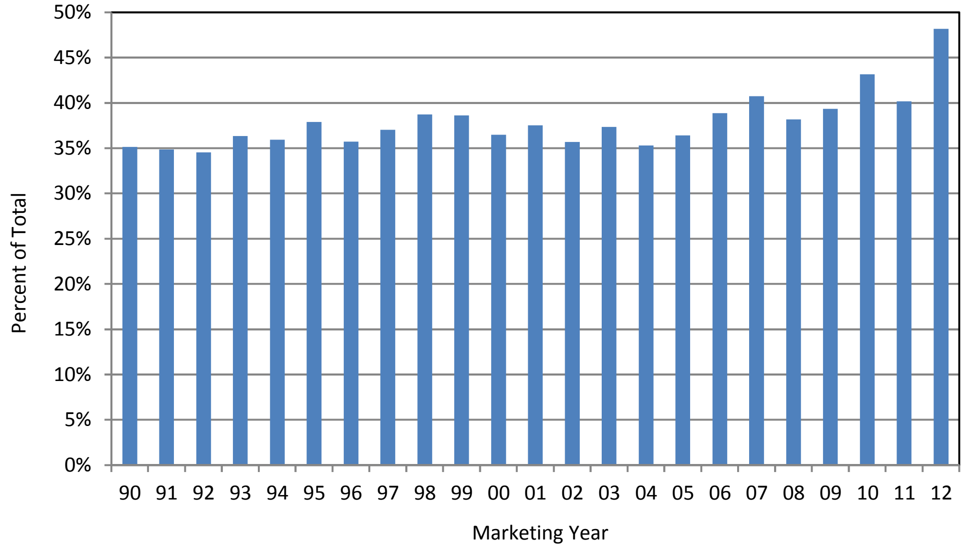


Figure 58. Estimated December-February Feed and Residual Usage, U.S. Corn, 1990-2012 Marketing Years

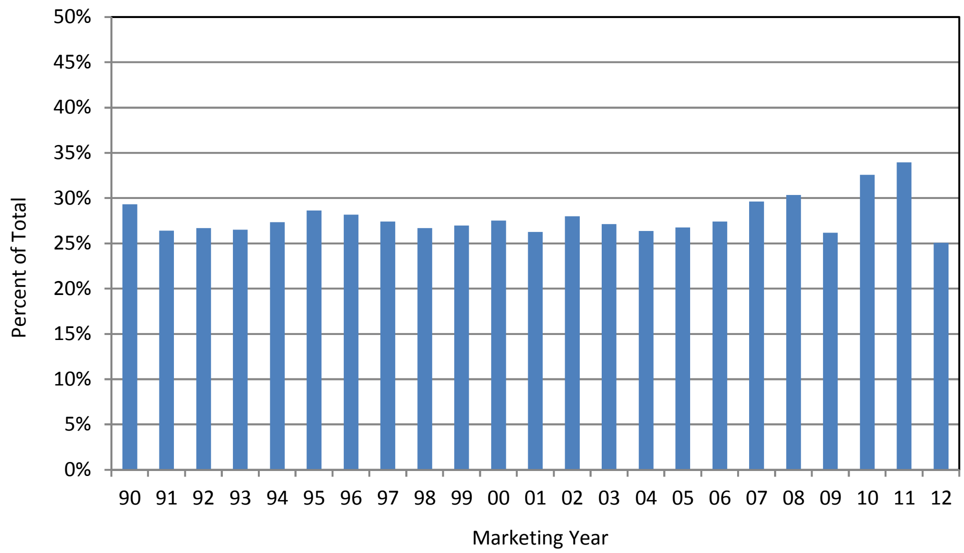


Figure 59. Estimated March-May Feed and Residual Usage, U.S. Corn, 1990-2012 Marketing Years

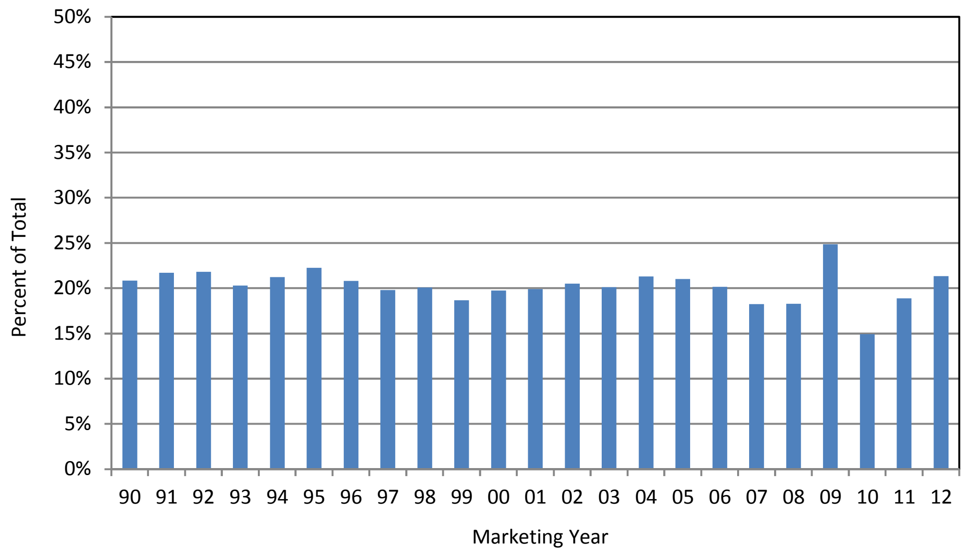


Figure 60. Estimated June-August Feed and Residual Usage, U.S. Corn, 1990-2012 Marketing Years

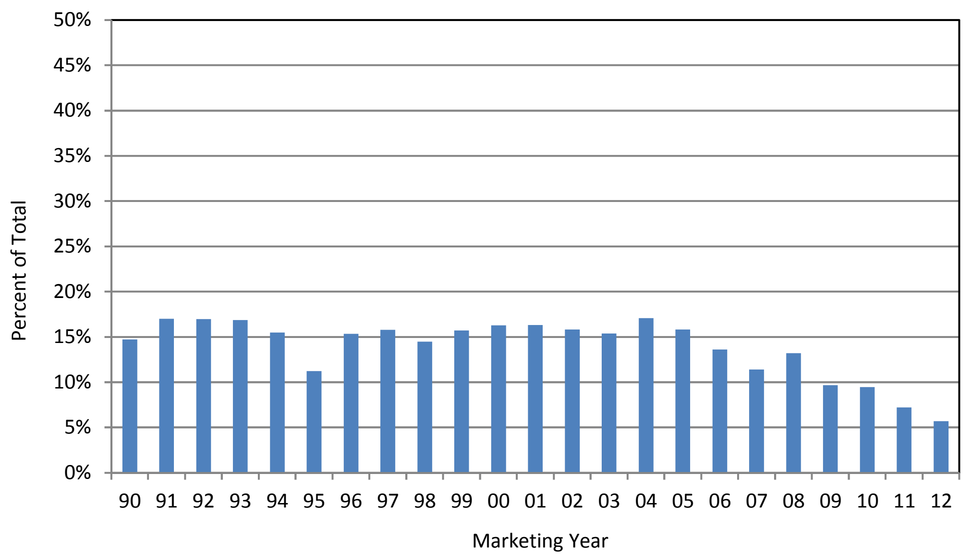


Figure 61. Estimated First Half of Marketing Year Feed and Residual Usage, U.S. Corn, 1990-2012 Marketing Years

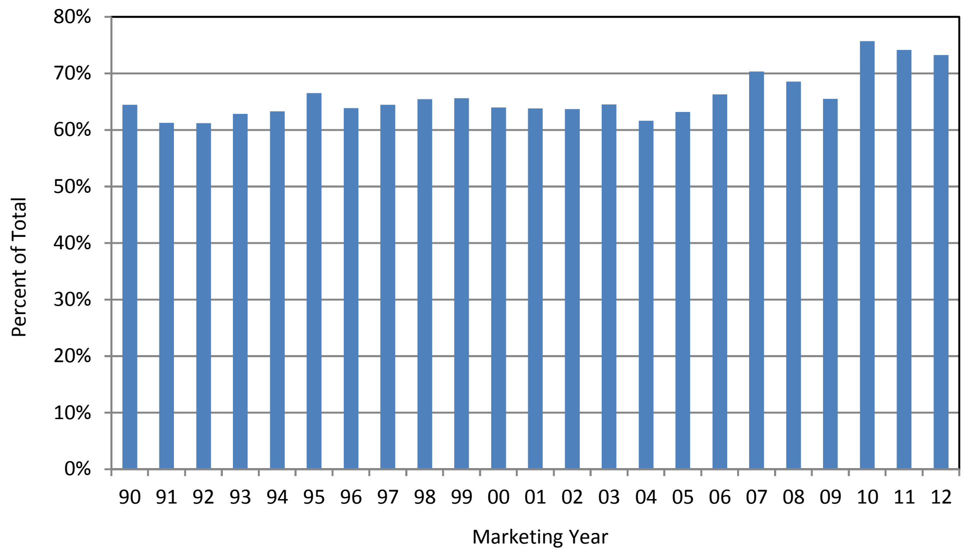


Figure 62. Estimated Second Half of Marketing Year Feed and Residual Usage, U.S. Corn, 1990-2012 Marketing Years

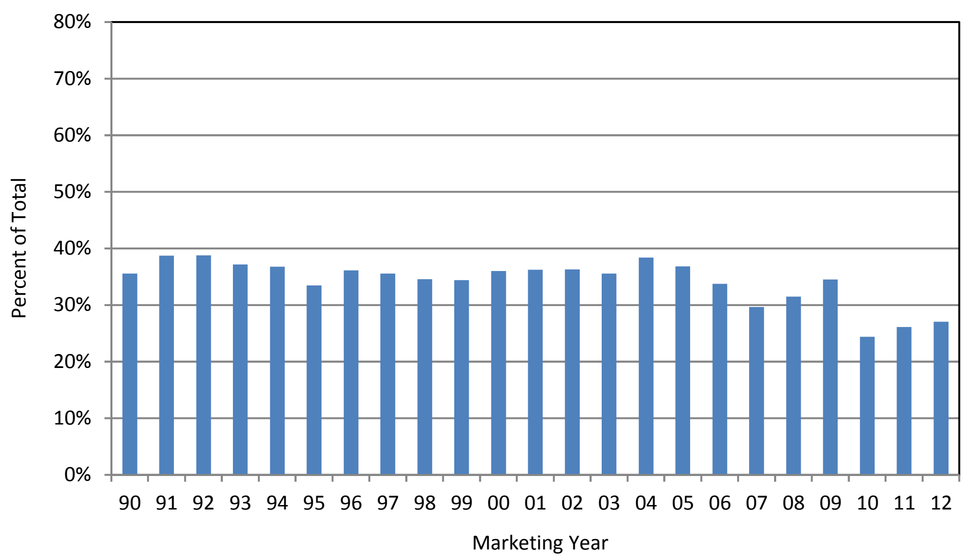


Figure 63. Estimated June-August Feed and Residual Usage, Wheat, U.S. Corn, 1990-2012 Marketing Years

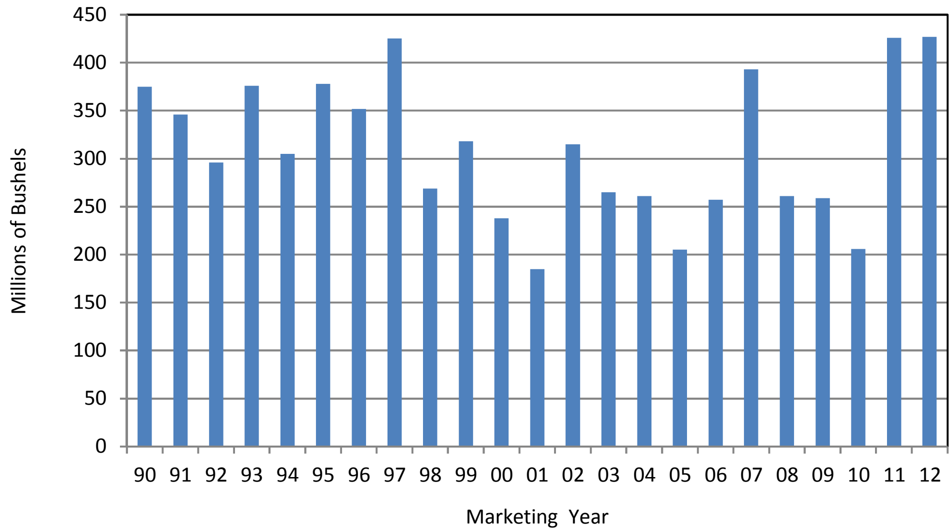


Figure 64. Estimated June-August Feed and Residual Usage, Combined U.S. Corn and Wheat, 1990-2012 U.S. Corn Marketing Years

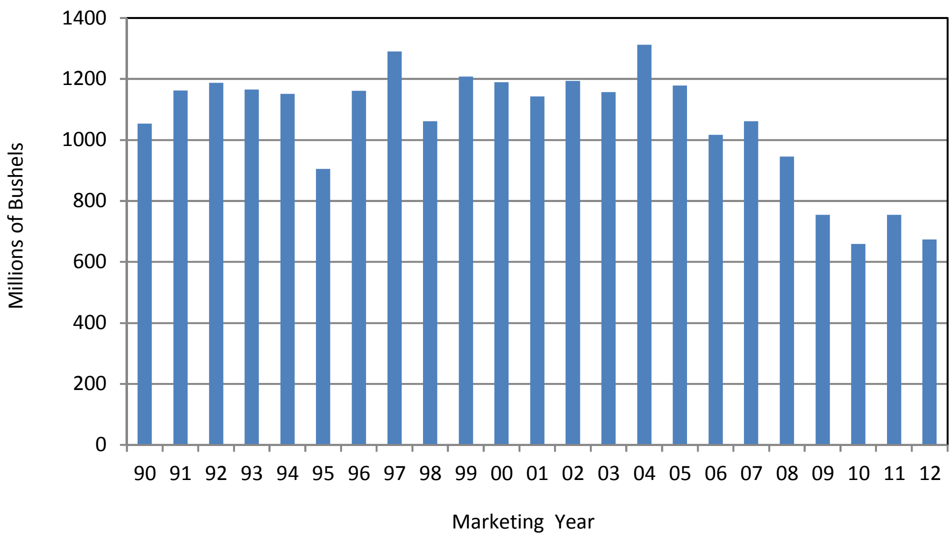


Figure 65. Estimated September-November and June-August Feed and Residual Usage, All U.S. Feed Grains plus Wheat, 1992-2012 Marketing Years

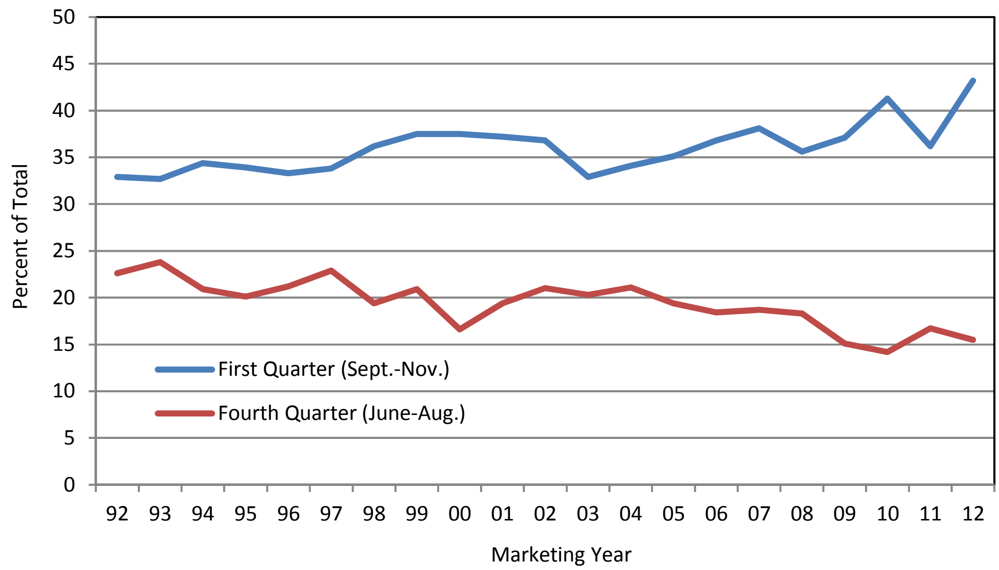


Figure 66. Domestic Production of U.S. Ethanol by Quarter, 1990-2012 Marketing Years.

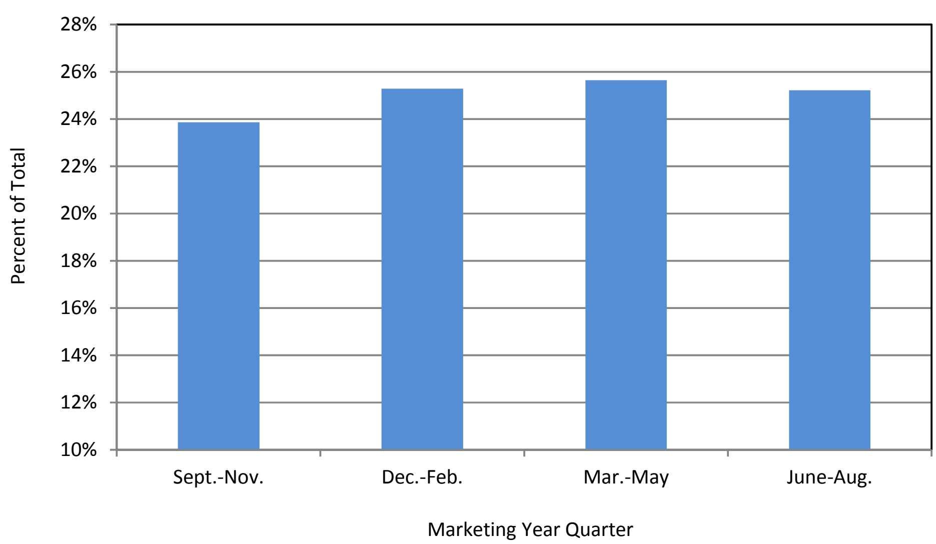


Figure 67. Implied Domestic Production of U.S. Distiller's Grains by Quarter, 1990-2012 Marketing Years.

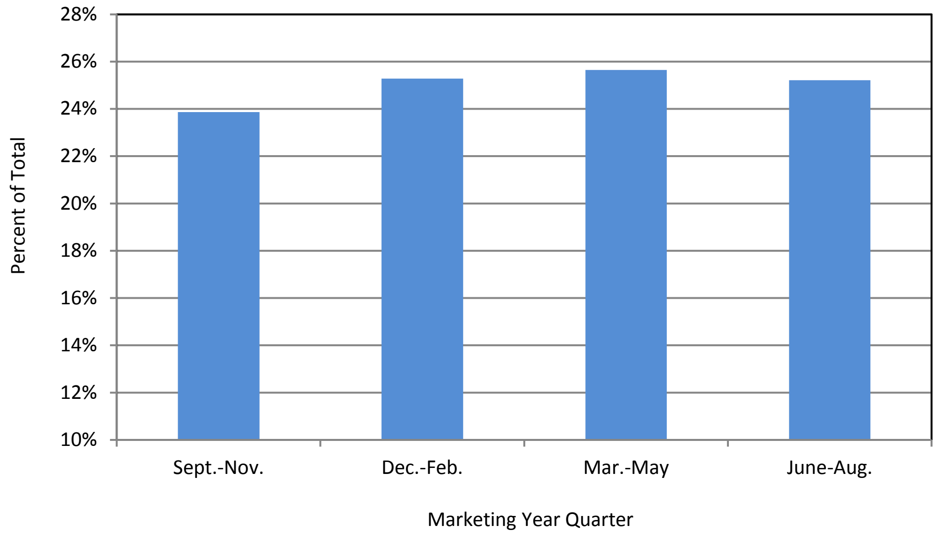


Figure 68. Apparent Domestic Usage of U.S. Distiller's Grains by Quarter, 1990-2012 Marketing Years

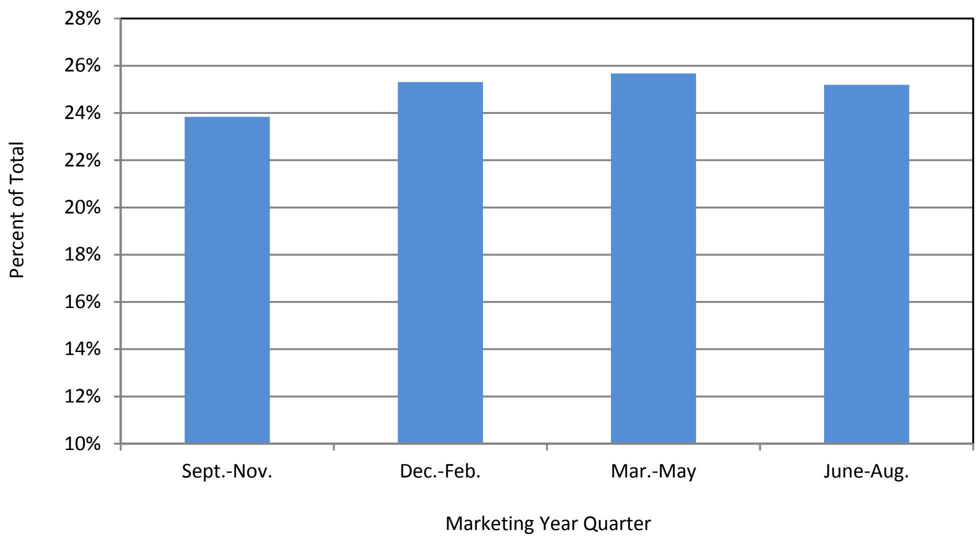


Figure 69. U.S. Exports of Distiller's Grains by Quarter, 1990-2012 Marketing Years.

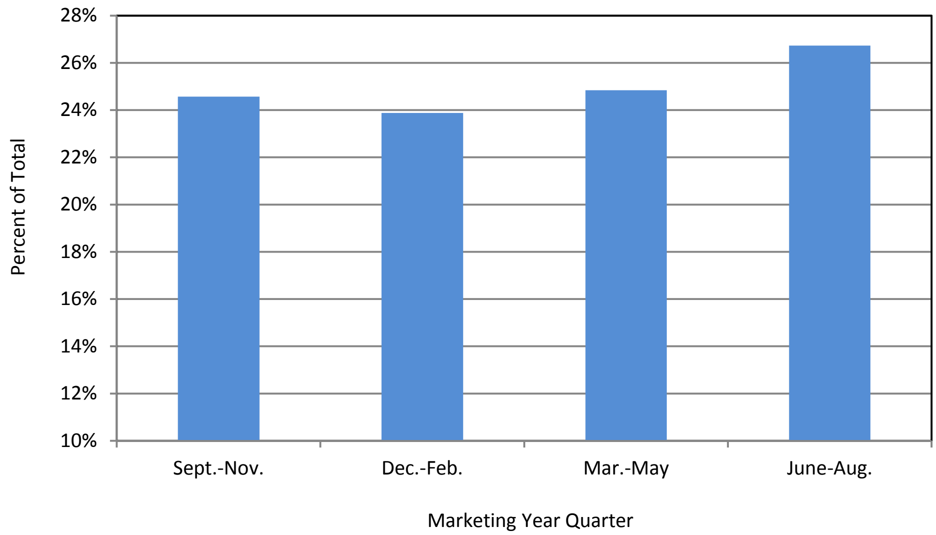


Figure 70. Estimated Quarterly Feed and Residual Usage by Marketing Year, U.S. Corn, 1990-2012 Marketing Years

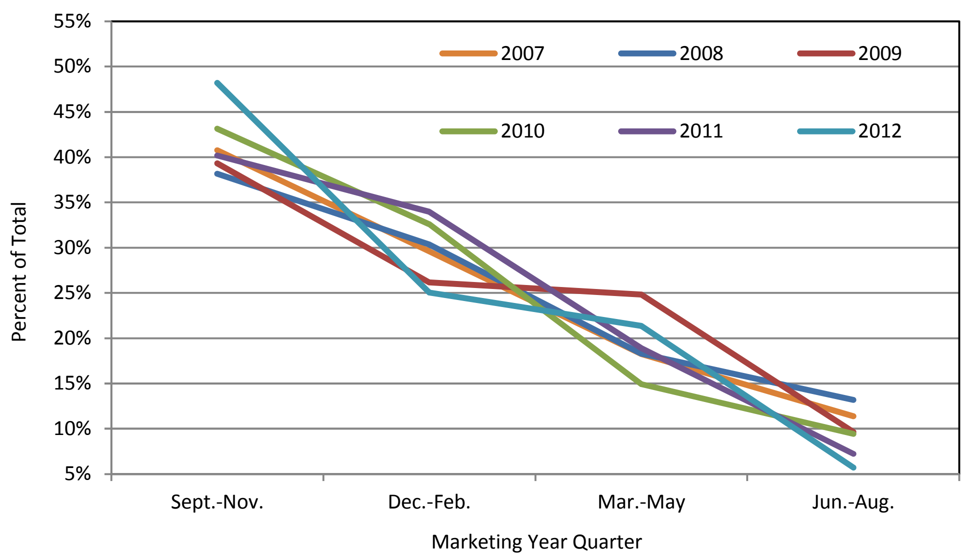


Figure 71. Daily Change in Nearby Futures Prices Following the Release of NASS *Grain Stocks* Reports, U.S. Corn, January 1991-September 2013

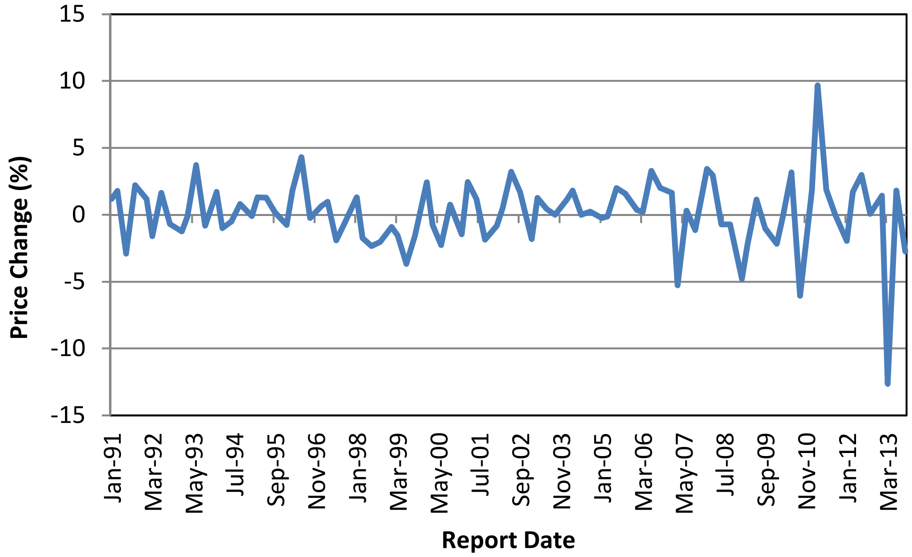


Figure 72. Relationship between Daily Changes in Nearby Futures Prices Following the Release of NASS *Grain Stocks* Reports and Market Surprise for NASS Implied Usage Estimates, U.S. Corn, January 1991-September 2013

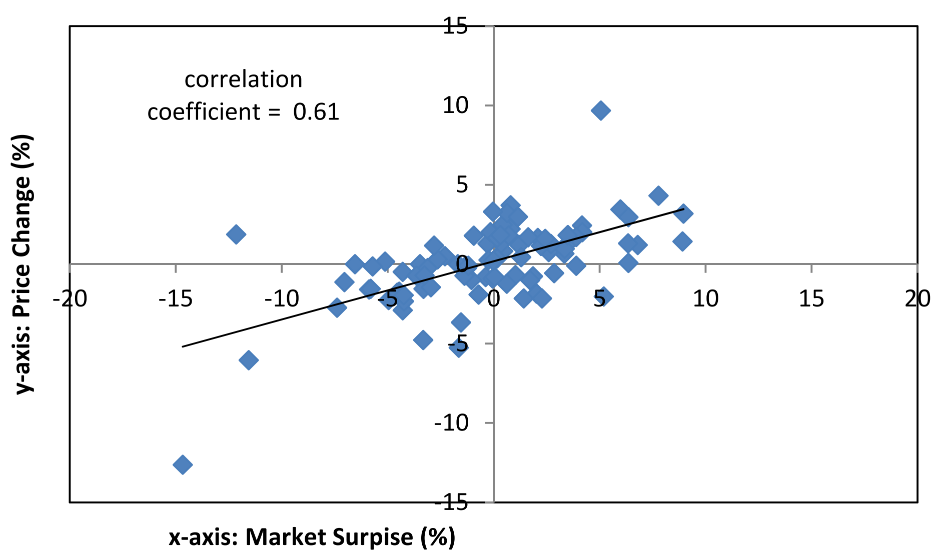


Figure 73. Daily Change in Nearby Futures Prices Following the Release of NASS *Grain Stocks* Reports, U.S. Soybeans, January 1991-September 2013

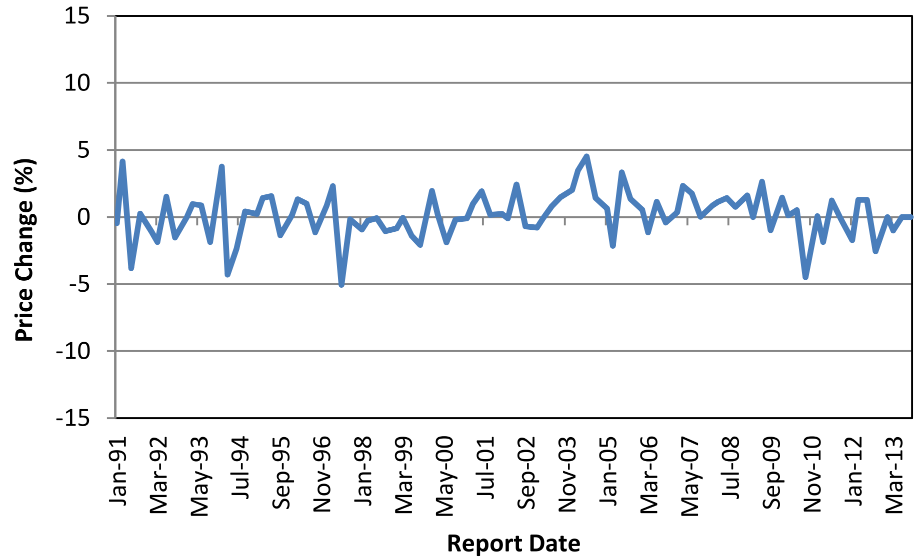


Figure 74. Relationship between Daily Changes in Nearby Futures Prices Following the Release of NASS *Grain Stocks* Reports and Market Surprise for NASS Implied Usage Estimates, U.S. Soybeans, January 1991-September 2013

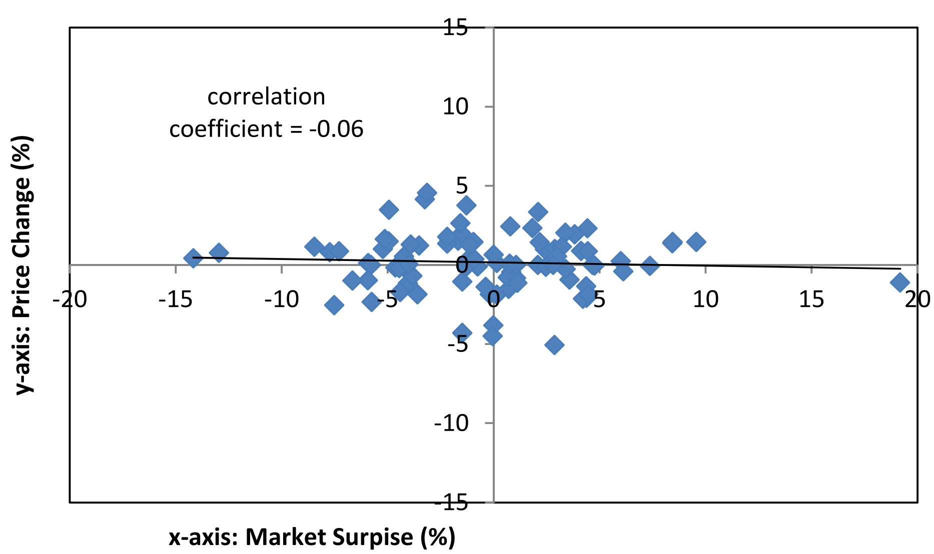
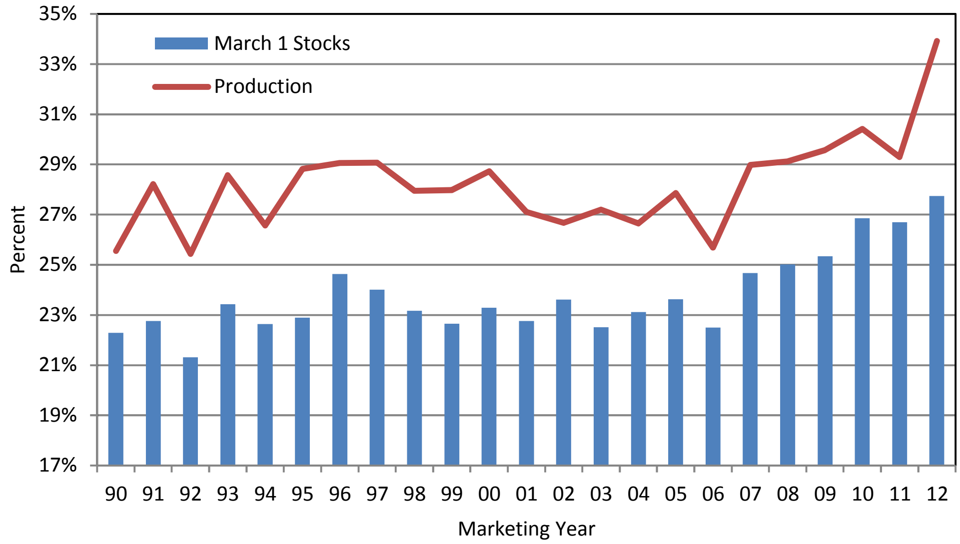
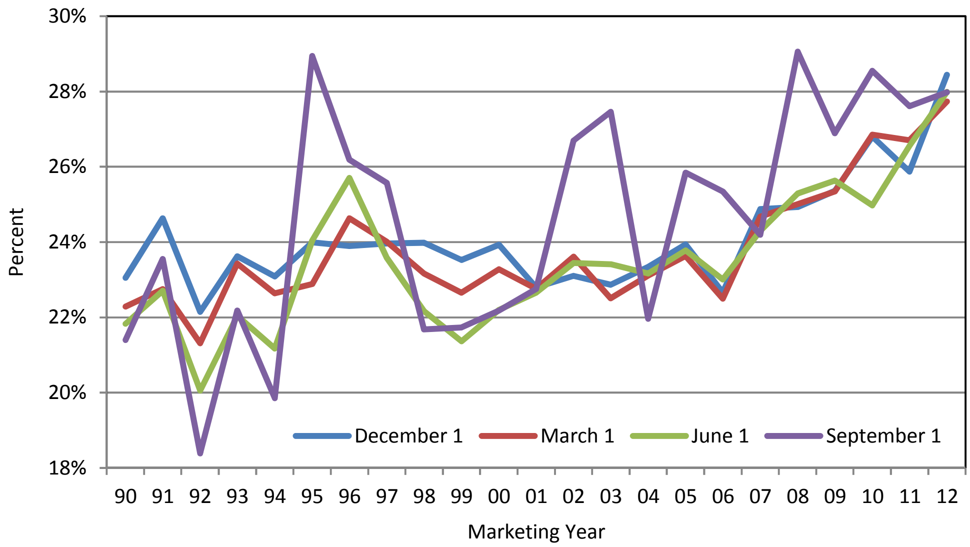


Figure 75. U.S. Corn Production and Stocks Outside of 7-State Area, 1990-2012 Marketing Years



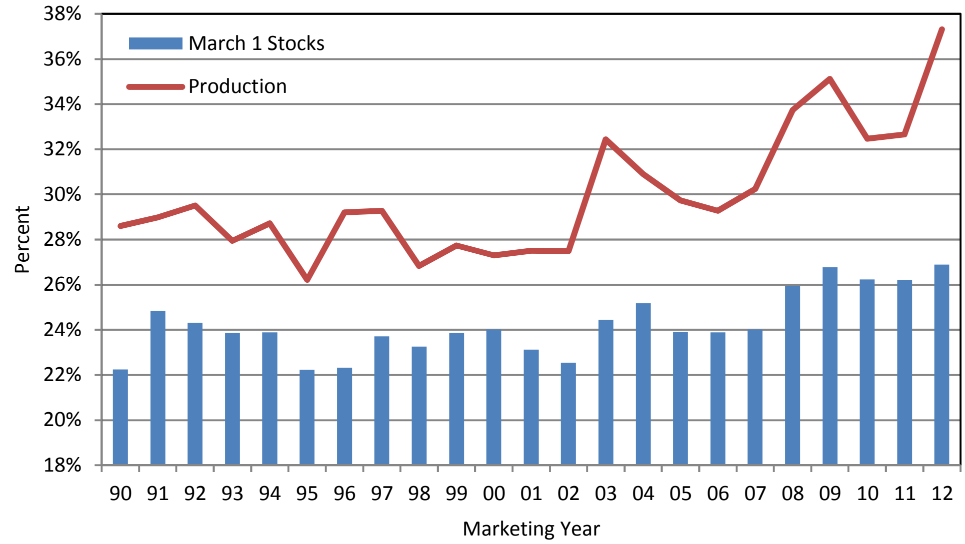
Note: 7-state area includes Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, and Ohio

Figure 76. U.S. Corn Stocks Outside of 7-State Area by Quarter, 1990-2012 Marketing Years



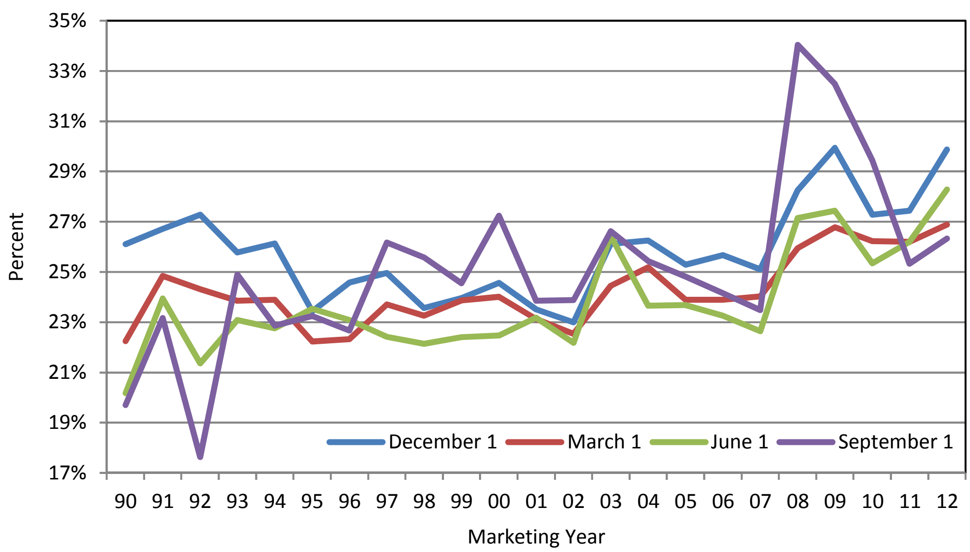
Note: 7-state area includes Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, and Ohio

Figure 77. U.S. Soybean Production and Stocks Outside of 7-State Area, 1990-2012 Marketing Years



Note: 7-state area includes Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, and Ohio

Figure 78. U.S. Soybean Stocks Outside of 7-State Area by Quarter, 1990-2012 Marketing Years



Note: 7-state area includes Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, and Ohio

Figure 79. U.S. Grain Storage Capacity, 2000-2012 Marketing Years

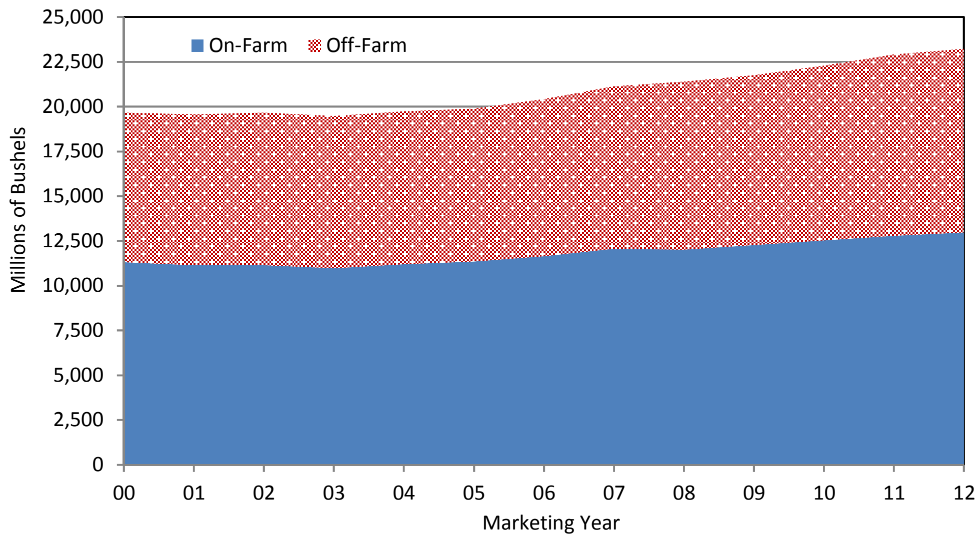


Figure 80. U.S. Grain Storage Capacity, Percent of Total, 2000-2012 Marketing Years

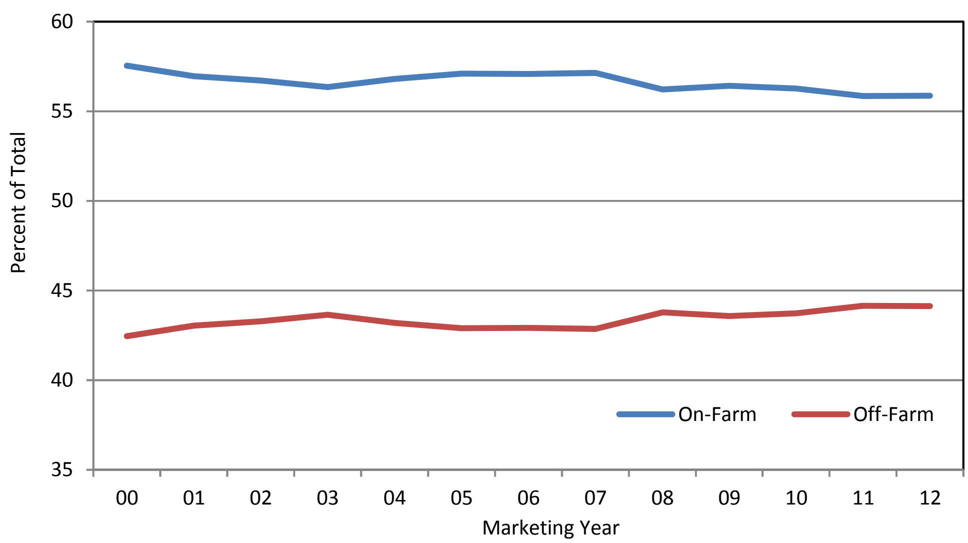


Figure 81. NASS December 1 On-Farm Stocks Estimates, Imputation Rates, 2001-2012 Marketing Years

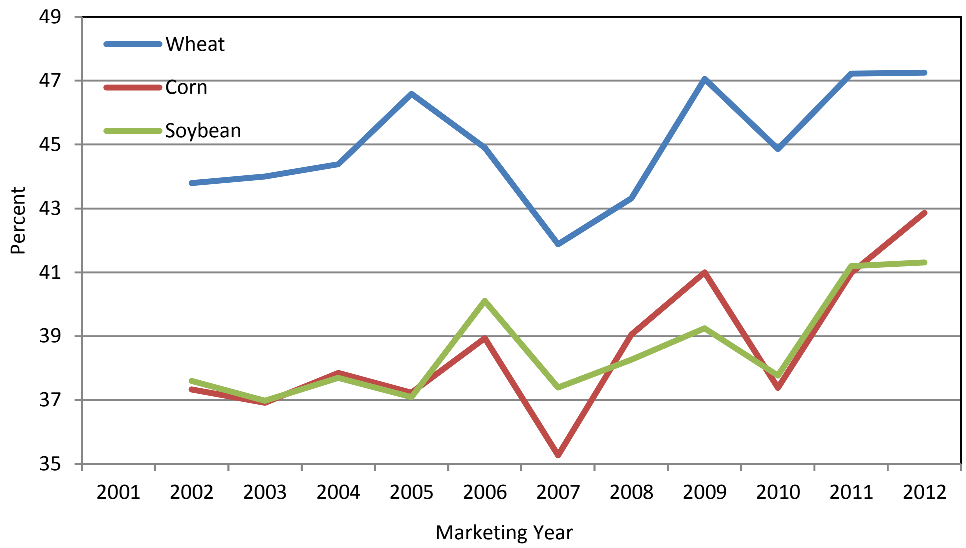


Figure 82. NASS March 1 On-Farm Stocks Estimates, Imputation Rates, 2001-2012 Marketing Years

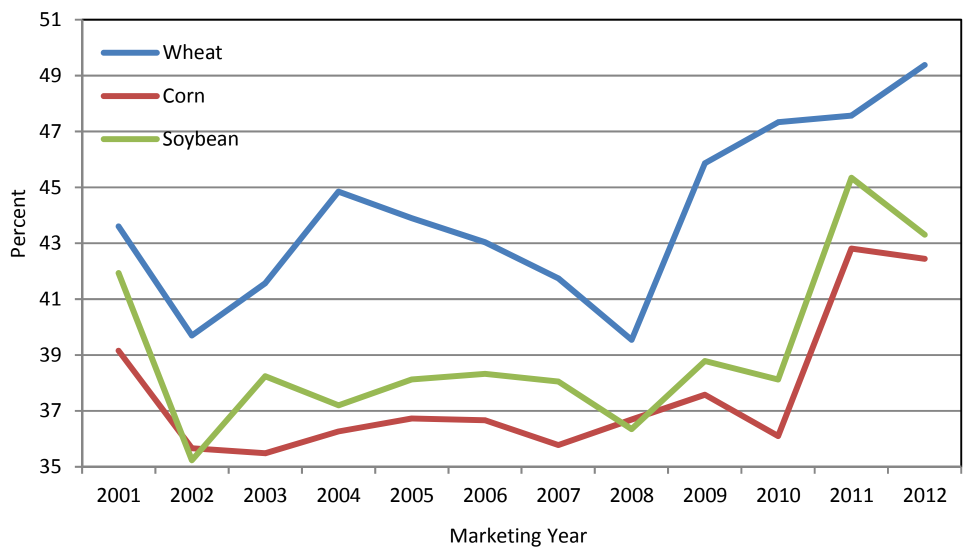


Figure 83. NASS June 1 On-Farm Stocks Estimates, Imputation Rates, 2001-2012 Marketing Years

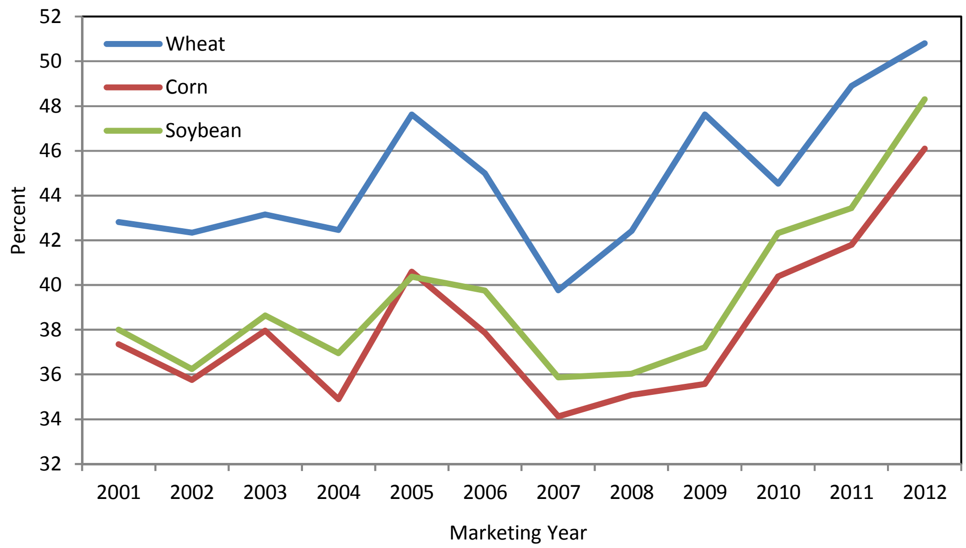


Figure 84. NASS September 1 Stocks Estimates, Imputation Rates, 2001-2012 Marketing Years

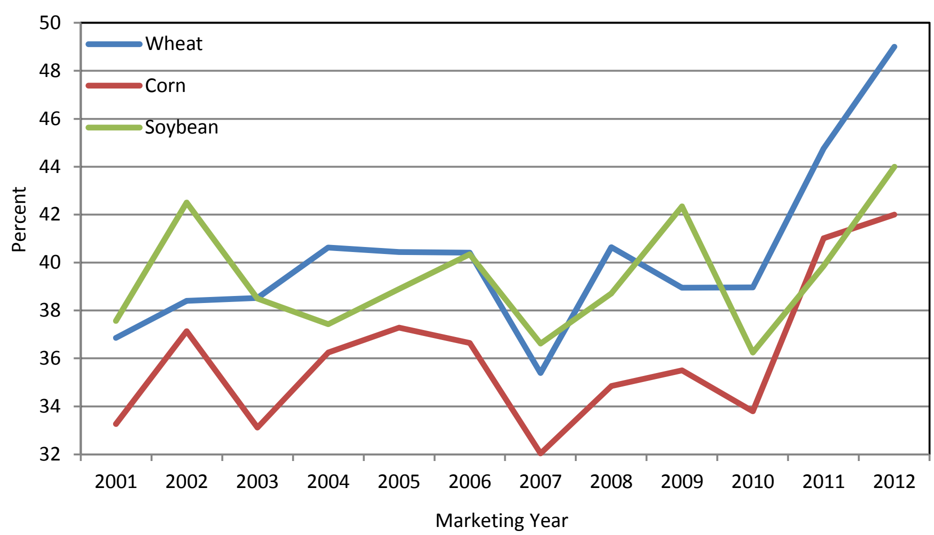
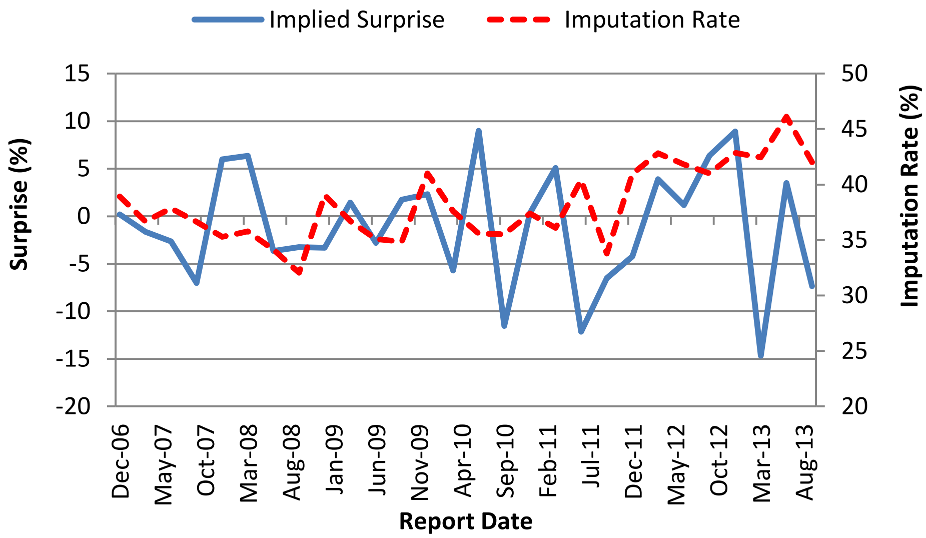
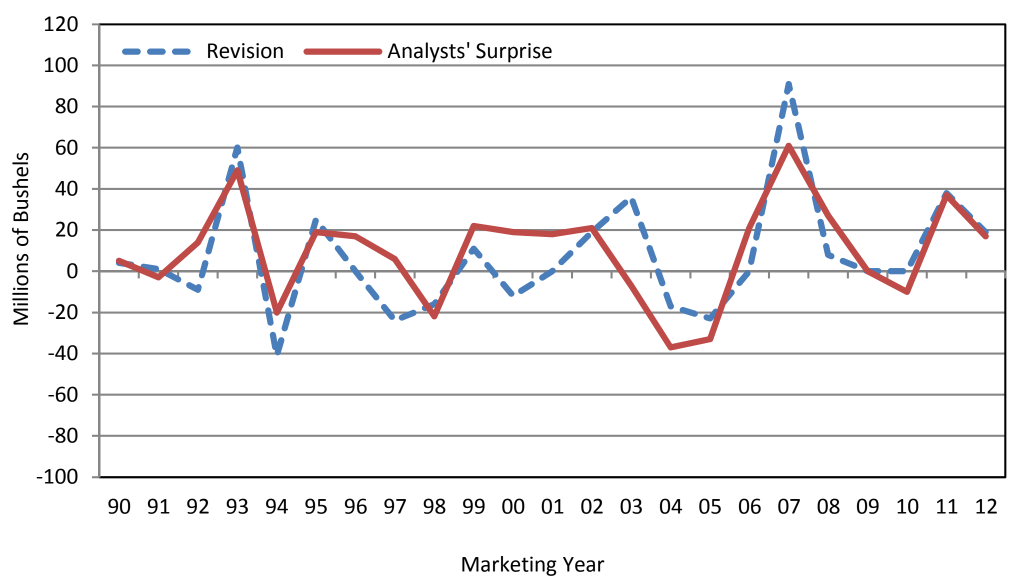


Figure 85. Surprise in NASS Implied Usage Estimates and Survey Imputation Rates for NASS Stocks Estimates, U.S. Corn, December 2006-September 2013 *Grain Stocks* Reports



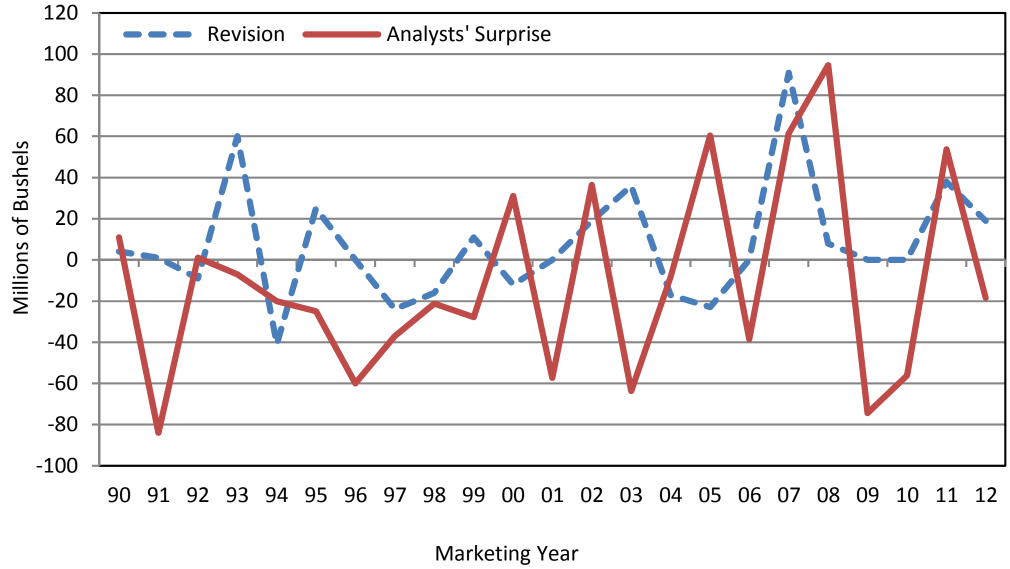
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 86. Market Surprise for NASS September 1 Stocks Estimates and NASS September Production Revisions, U.S. Soybeans, 1990-2012 Marketing Years



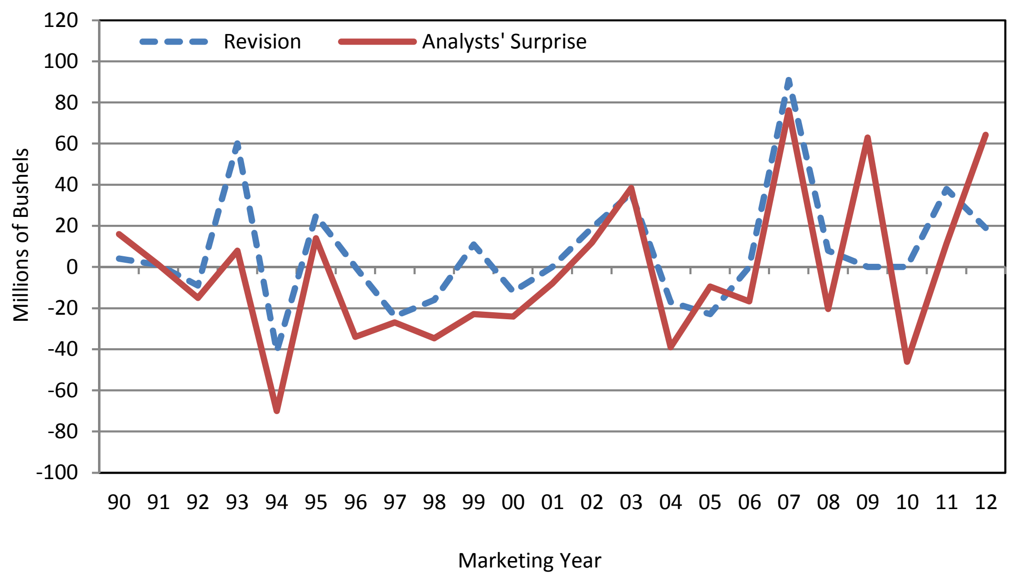
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 87. Market Surprise for NASS December 1 Stocks Estimates and NASS September Production Revisions, U.S. Soybeans, 1990-2012 Marketing Years



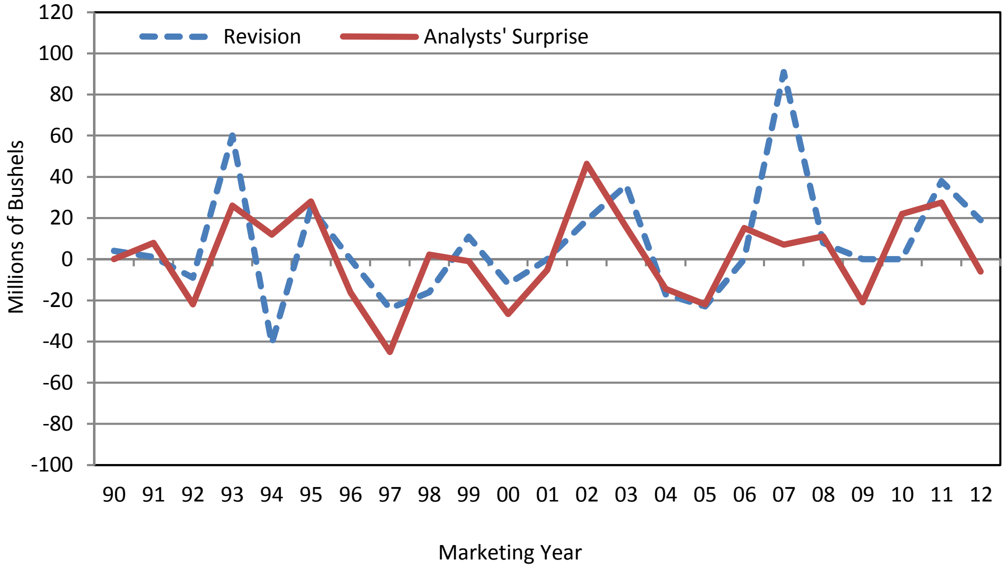
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 88. Market Surprise for NASS March 1 Stocks Estimates and NASS September Production Revisions, U.S. Soybeans, 1990-2012 Marketing Years



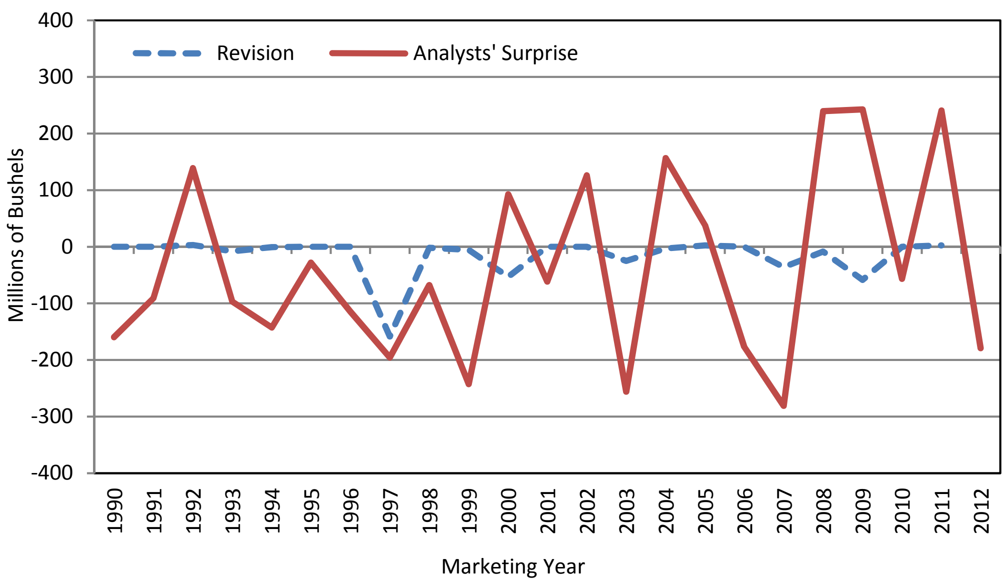
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 89. Market Surprise for NASS June 1 Stocks Estimates and NASS September Production Revisions, U.S. Soybeans, 1990-2012 Marketing Years



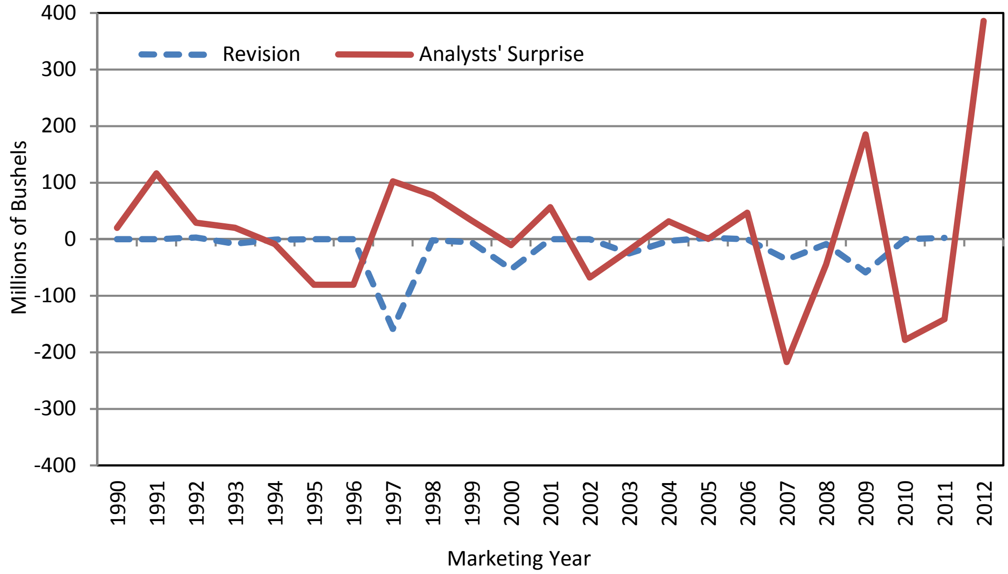
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 90. Market Surprise for NASS December 1 Stocks Estimates and NASS Production Revisions, U.S. Corn, 1990-2011 Marketing Years



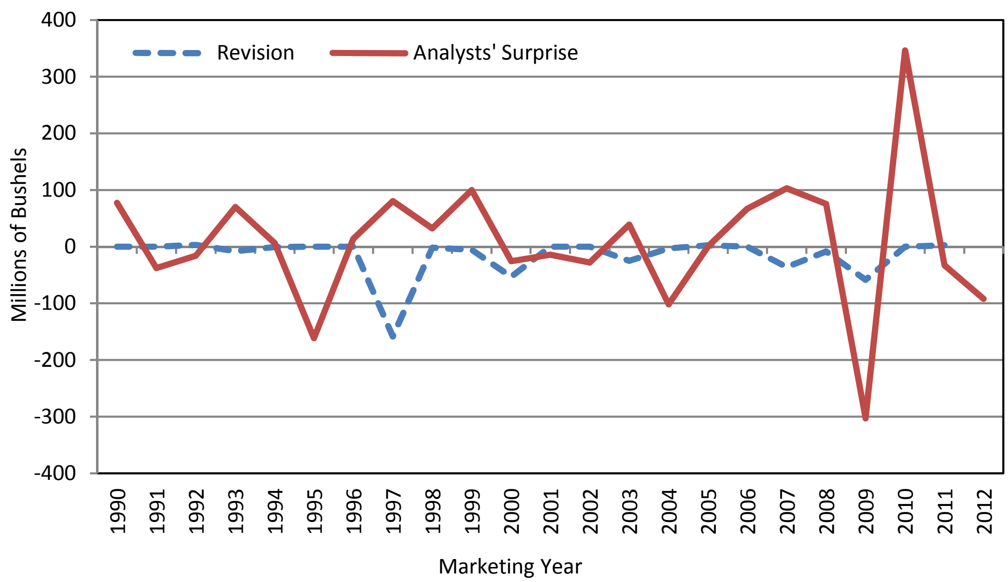
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 91. Market Surprise for NASS March 1 Stocks Estimates and NASS Production Revisions, U.S. Corn, 1990-2011 Marketing Years



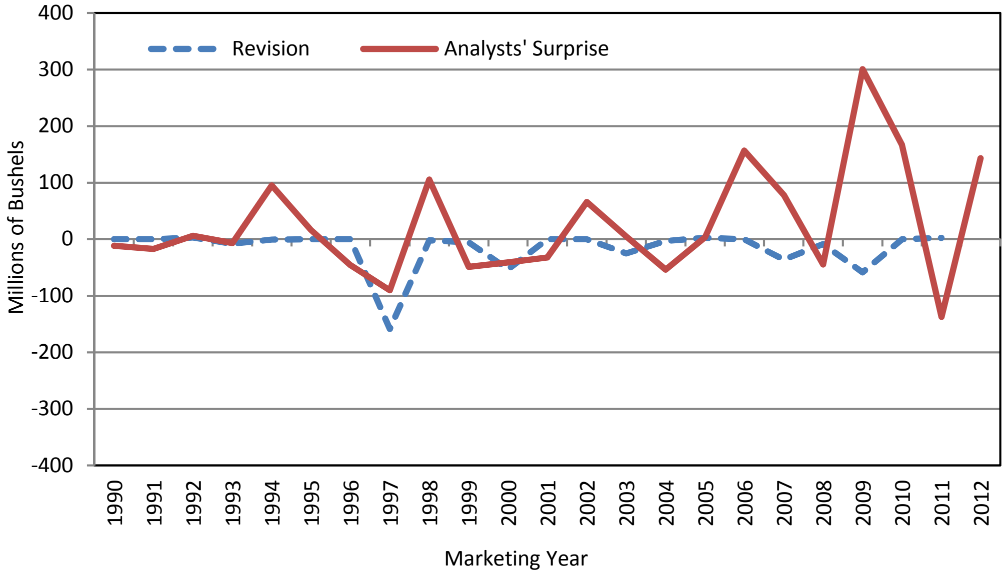
Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 92. Market Surprise for NASS June 1 Stocks Estimates and NASS Production Revisions, U.S. Corn, 1990-2011 Marketing Years



Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 93. Market Surprise for NASS September 1 Stocks Estimates and NASS Production Revisions, U.S. Corn, 1990-2011 Marketing Years



Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.

Figure 94. Simulated Revisions to NASS Corn Production Estimates based on September Revisions to NASS Soybean Production Estimates, 1990-2012 Marketing Years

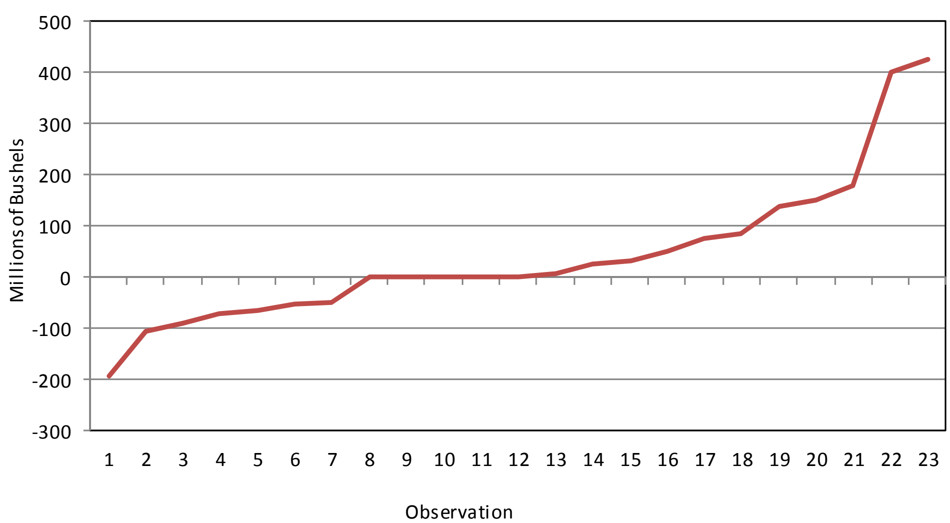


Figure 95. Percentage Change in U.S. Corn and Soybean Production Estimates from January to Final, 1990-2011 Marketing Years

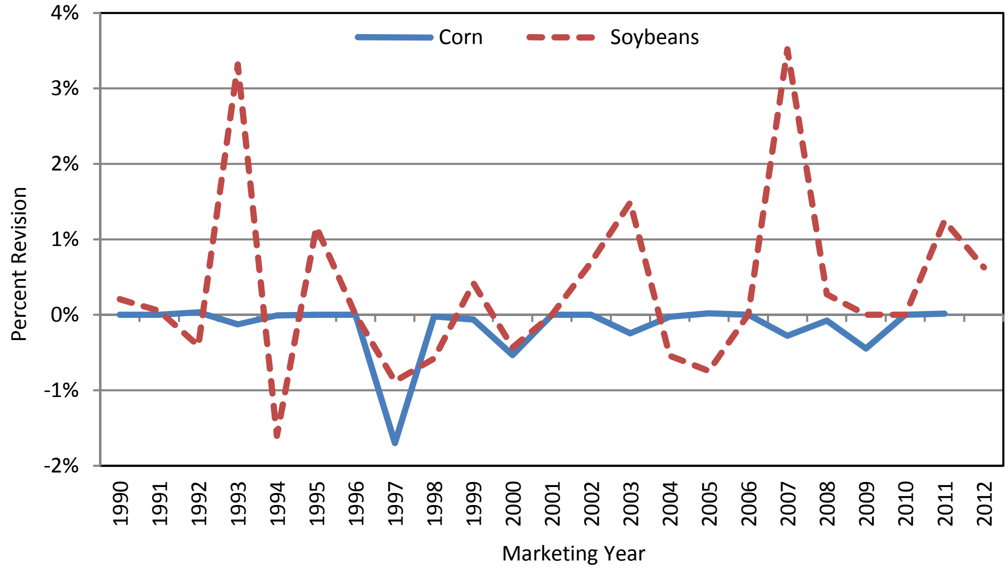
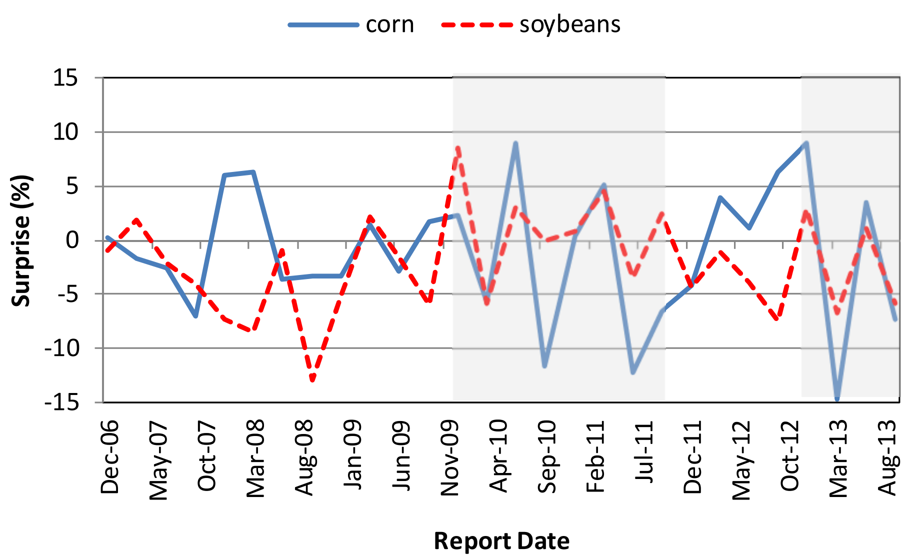


Figure 96. Surprise in NASS Implied Usage Estimates for NASS Stocks Estimates, U.S. Corn and Soybeans, December 2006-September 2013 *Grain Stocks* Reports



Note: A positive (negative) surprise occurs when analyst estimates are lower (higher) than the actual.