



Understanding “Implied Ear Weight” in USDA’s August Corn Yield Forecast

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The [National Agricultural Statistics Service \(NASS\)](#) of the USDA is responsible for making U.S. crop production forecasts and estimates. NASS released the first survey-based forecast of the [size of the 2016 U.S. corn crop](#) on August 12. New forecasts will be issued on September 12, October 12, and November 9 and the final estimate of yield and production will be released in the second week of January 2017. The August 2016 corn yield forecast was 175.1 bushels per acre, which would be a new record if realized. The yield projection was also a major surprise to the market, with average market expectations closer to 170-171 bushels (*farmdoc daily*, [August 12, 2016](#)). After the report was released there was considerable discussion of the “implied ear weight” that NASS calculates for each monthly forecast and final estimate. Specifically, the implied ear weight for the August 2016 yield forecast was the largest of the last 13 years, a period that includes several very good growing seasons such as 2004, 2009, and 2014. The very high implied ear weight raises the question whether NASS may have overestimated yield potential by using an assumed ear weight that is too high. However, it must also be said there appears to be a widespread misunderstanding of how the implied ear weight is actually derived and therefore how it should be interpreted. Some of that misunderstanding may stem from a lack of knowledge about the NASS methodology for generating monthly yield forecasts, but NASS also provides very few details on the computation of implied ear weights. The purpose of this article is to provide a better understanding of the NASS implied ear weight calculation and analyze available data to determine how likely it is that the August 2016 ear weight estimate will decline substantially.

NASS Corn Yield Forecasting Methodology

We begin with a review of the NASS corn yield forecasting methodology. Further details can be found in these NASS publications ([Vogel and Bange, 1999](#); [NASS, 2012](#)), research reports ([Irwin and Good, 2006](#); [Irwin and Good, 2011](#); [Irwin, Sanders and Good, 2014](#)), and *farmdoc daily* articles ([August 28, 2013](#); [August 29, 2014](#); [September 4, 2014](#)). From our experience, much of the misunderstanding of USDA yield estimates for corn (and other crops) revolves around the fact that the USDA uses two types of surveys to collect data for the monthly NASS production forecasts in August through November. These are referred to as the Agricultural Yield Survey (or the farmer-reported survey) and the Objective Yield

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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.

For the August 2016 forecast, the Agricultural Yield Survey (AYS) included 22,144 operations for all crops and was conducted in 32 states for corn. The sample of farm operations surveyed was drawn from those who responded to the survey of planted acreage in June. The sampling design used to select the operations to be surveyed employs 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 will be interviewed each month from September through November. Most of the survey data are collected in electronic form using computer-assisted telephone interviewing. Each state is expected to achieve a minimum response rate of 80 percent.

In the August survey, respondents were asked to identify the number of acres of corn to be harvested and to provide a forecast of the final yield. Harvested acreage responses will be retained from month-to-month and the question will not be asked in subsequent surveys. The AYS, however, does contain a distressed acres sub-survey that targets specific crops in states that have experienced extreme weather conditions in order to measure changes when extreme weather does occur. Respondents will be asked to update yield forecasts in subsequent surveys. Note that respondents are not asked to estimate plant population or average ear weights, only yield per acre.

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 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 (under-estimate yield potential) particularly under drought conditions. 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. Some have referred to this survey as “ground truthing” the yield estimates reported by farm operators in the AYS. The sample of fields for the OYS survey is selected from farms that reported corn planted or to be planted in the June survey of acreage. Samples are selected in the 10 principal corn producing states. 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. For the August 2016 OYS, a total of 4,544 plots were sampled for corn, soybeans, cotton, and winter wheat.

Two counting areas, or plots, are randomly selected in each field. Objective measurements (such as counts of plants and ears) 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. During the August survey, the operator is asked to verify, field-by-field, the acreage reported in June.

For corn, each of the two independently located sample plots in a field consists of two parallel 15 foot sections of row. Each plot is selected by using a random number of rows along the edge of the field and a random number of paces into the field. 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. Harvest loss is measured in separate areas near the yield plots.

Data collected from each corn plot during the forecast cycle are used to measure size of the plot area and to measure or forecast the number of ears and grain weight. These data include (as available) row width, number of stalks per row, number of stalks with ears or ear shoots per row, number of ears with kernels, kernel row length, ear diameter, ear weight in dent stage, weight of shelled grain, moisture content, total

ear weight of harvested unit, lab weight of sample ears, weight of grain from sample ears, and moisture content of shelled grain from sample of mature ears.

At each visit, the enumerator establishes a corn maturity category for the plot, ranging from 1 (no ear shoots) to 7 (mature). Prior to the blister stage (see [this publication](#) for an overview of corn growth stages), the number of ears is forecast based on the number of stalks, ear shoots, or ears and both the weight per ear and harvest loss are forecast based on the 5-year average. From the blister through the dough stage, the weight per ear is forecast based on kernel row length and harvest loss is forecast based on the past 5-year average. Ear weight is measured in the dent and/or mature stage. Harvest loss is measured following harvest.

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. Forecasts are based on conditions as of the survey date and projected assuming normal weather conditions for the remainder of the growing season. The OYS forecast of gross corn yield then is based on the following formula:

$$\text{Gross Yield} = [\text{number of ears} \times \text{weight per ear at 15.5\% moisture}] \div 56$$

Number of ears and ear weight are either forecast or actual and 56 is a conversion from weight to bushels.

The state average gross corn 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) 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 be liberal in estimating final yields (over-estimate yield potential). This tendency is quantified and factored into the official yield forecasts.

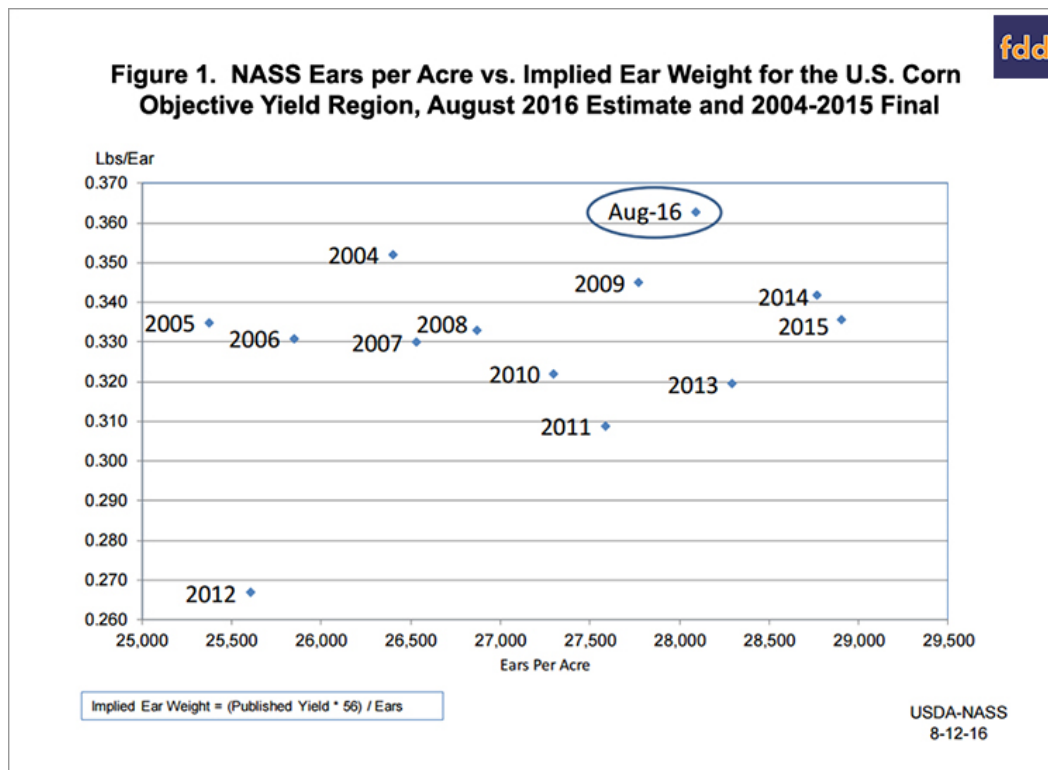
The survey and forecasting procedures described above produce a number of indicators of the net yield of corn from the AYS and OYS. In August these indicators include the average field level yields from the OYS, average state level counts from the OYS, and the average yield reported by farm operators 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. This process is completed independently in each state and at the 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.

Implied Ear Weight

As indicated above, the yield of corn is essentially a function of the number of ears per acre and the weight of each ear (see [this recent article](#) by Emerson Nafziger of the University of Illinois for additional details). So, to understand the factors driving a yield forecast it is helpful to know the underlying ear count per acre and average ear weight. For each monthly yield forecast and final estimate, NASS calculates these statistics but they are not published in the monthly *Crop Production* reports. Instead, the average ears per acre and ear weight are shown graphically in the [executive summary](#) released in tandem with the reports. Figure 1 shows the calculated ears per acre and ear weight for the August 2016 yield forecast along with the final calculation for the previous 12 years. Two things are notable about the observation for August 2016. First, the implied ear weight, at about 0.363 pounds is high in comparison to recent years (2014, 2015) as well as earlier years with very good growing seasons (2004, 2009). The relatively high implied ear weight raises the question whether NASS may have overestimated yield potential by using an assumed ear weight that is too high. Second, ears per acre, about 28,100, is more than 1,000 ears lower than in 2014 and 2015. This could be due to lower plant populations, emergence problems, or pollination problems, or some combination of all three.

To assess whether the August 2016 ear weight is “too high” it is important to understand how NASS computes the implied ear weight. As shown in Figure 1, the calculation is as follows,

$$\text{Implied Ear Weight} = (\text{published yield forecast} \times 56) / \text{number of ears per acre.}$$



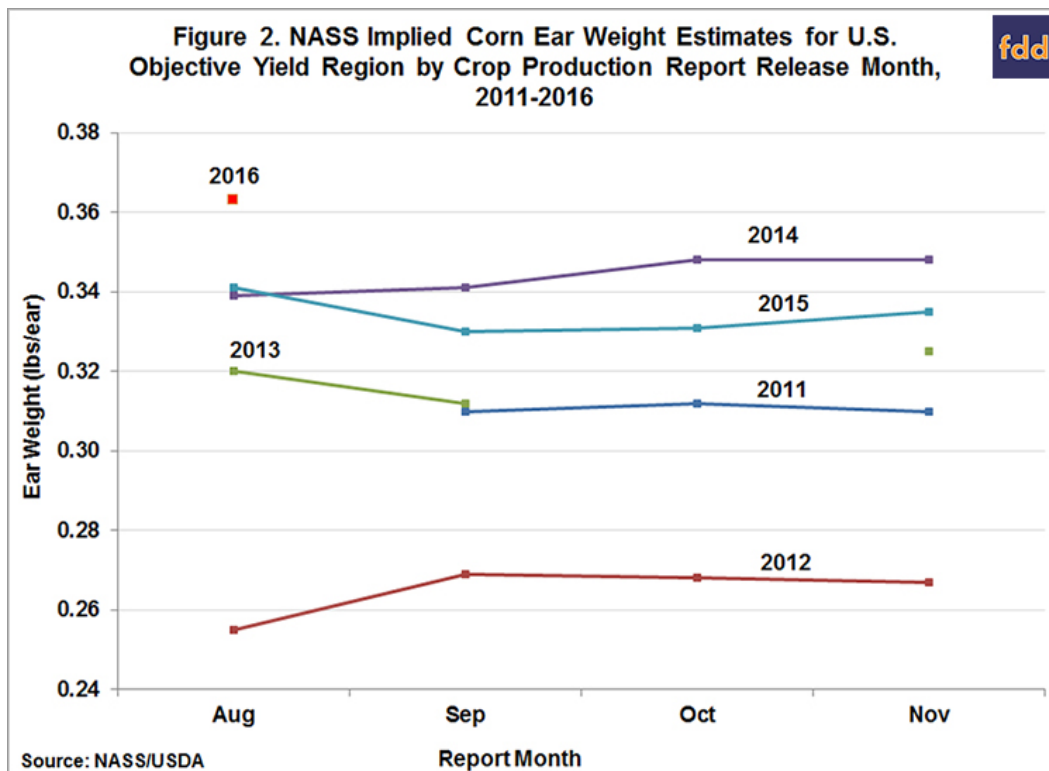
Some misunderstanding about this calculation probably stems from the lack of descriptive detail provided by NASS. First, the calculation is limited to the 10 states included in the objective yield survey, which means that data for states outside of the objective yield region do not impact the implied ear weight estimate. Second, while the published yield can be calculated for those 10 objective yield states, NASS does not report that average directly. Third, the ear count per acre and calculated implied ear weight are not reported directly, but must be read from the plot in Figure 1. For example, the weighted average yield forecast for the 10 states included in the OYS in August this year is calculated as 182 bushels, or 10,192 pounds. The average number of ears per acre in those 10 states appears to be estimated at 28,100. The calculated implied ear weight, then, is about 0.363 pounds.

Probably the biggest source of misunderstanding regarding the implied ear weight calculation is the failure to recognize that yield forecasts are derived from two independent surveys. The implied ear weight, then, is not an assumed ear weight or a measured ear weight, even though some elements of ear weight measurement or ear weight forecasts are used in the OYS. In the OYS procedure, NASS may use some combination of assumed or measured ear weight, depending on maturity of the crop. As described above, prior to the blister stage, 5-year average ear weights are assumed in OYS yield estimates and after blister stage, kernel counts are used to forecast ear weight. So, NASS does use some element of forecasting ear weights when making OYS yield estimates prior to actual harvest. However, there is no analogue available for the AYS yield estimates, where farm operators are only asked to report harvested acreage and yield. This means that any ear weight assumptions or calculations used by respondents to the AYS are not known. The key then to a proper understanding of the NASS calculation of “implied” ear weight is to realize it is based on the average population count from the OYS and the 10- state average yield forecast based on **both** the OYS and the AYS. In other words, the implied ear weight is a “hybrid” measure reflecting information from both the OYS and AYS surveys. The ear count per acre is drawn from the OYS but the average yield is based on both the OYS and AYS surveys. That is why NASS calls the measure “implied” rather than “assumed” or “measured.” There is only one way that the derived ear weight measure reported by NASS can equal the assumed 5-year

average ear weights for the OYS—the average ear weight and population used by farm operators in responding to the AYS would have to be exactly the same as the 5-year average weight and population assumed by NASS for the OYS. Obviously, this is highly unlikely to be the case, and hence, one should not equate derived ear weights reported by NASS as the same thing as the 5-year average ear weight used by NASS in one part of the yield estimation process.

Early season NASS calculations of ear weight can differ from final estimates of ear weight for a number of reasons. First, the final estimate of the number of ears per acre may differ from early season estimates, although the estimates of plant populations reported for the 10 objective yield states do not change much from month-to-month. Those plant population estimates are not reported in “real” time, but are summarized in the [Crop Production Annual Summary](#) report. Second, early season forecasts of ear weight in the OYS based on 5-year averages may not accurately reflect ear weights in the current year. Third, early season yield expectations reported by producers in the AYS may differ from their final estimates. As the crop reaches maturity so that ear weight can be measured in the OYS and as harvest progresses so that farmer yield expectations become more accurate, the calculation of average ear weight also becomes more accurate.

Evidence on the actual variation of NASS implied ear weight estimates across report release months is presented in Figure 2. The ear weight data shown in the chart are approximate values based on the charts found in executive summaries for the August-November reports over 2011-2016. The August 2011 estimate is missing because the ear weight chart was not presented in the executive summary for that report and the October 2013 estimate is missing because a *Crop Production* report was not issued due to the federal government shutdown. Also note that final ear weight estimates are not released in the *Crop Production Annual Summary*, while, curiously, final ear counts per acre are released. Figure 2 shows there is some variation across the report months for the reasons outlined above, with an average change from August to November (September to November in 2011) of +0.004 pounds per ear, so there is a slight tendency for the ear weight estimates to increase over time. The average absolute change is 0.006 pounds per ear, or 2.1 percent. The largest August-November change, +0.12 pounds per ear, occurred in 2012; perhaps not surprising given the extraordinary nature of the drought conditions that year.



In sum, the available data on NASS ear weight estimates indicates they change relatively little once the initial estimate is made in August. This means one should be quite cautious in concluding that the August 2016 ear weight estimate is an outlier that will be adjusted downwards substantially in future *Crop Production* reports. Using the data from 2011-2015, we can project that the November 2016 estimate is likely to be in the range of 0.363 +/- 0.006 pounds per ear, or 0.357 to 0.369 pounds. So, if historical patterns hold, the final (November) estimated average ear weight is likely to exceed the previous high of about 0.352 in 2004 and remain well above the averages for 2014 and 2015.

Implications

This review of the USDA's corn yield and production forecasting procedures is a reminder of the size and robustness of the survey and forecasting methodology. The methodology is time-tested and has no parallel in the private sector. One of the criticisms of the August corn yield forecast this year was that assumptions about ear weight included in the forecast process may have been too aggressive, resulting in a forecast that overstates actual yield potential. The "too high" ear weight argument may reflect some misunderstanding of the yield forecasting methodology used by NASS, the USDA agency responsible for making the forecasts. In particular, the implied ear weight reported by NASS is a "hybrid" measure reflecting information from both the objective yield survey (OYS) and agricultural yield survey (AYS). Any ear weight assumptions or calculations used by farm operator respondents to the AYS are not known and this makes it impossible to "back out" the 5-year average ear weight assumption used by NASS for the OYS side of the yield estimation process. Regardless, the available data on NASS ear weight estimates indicates they change relatively little once the initial estimate is made in August. This means one should be quite cautious in concluding that the August 2016 ear weight estimate is an outlier that will be adjusted downwards substantially in future *Crop Production* reports.

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