Kansas Wheat Yield Estimate - 2/27/23

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Abstract

This paper uses data from the U.S. drought monitor website (https://droughtmonitor.unl.edu) to predict both yields and harvested acres on a county level basis for Kansas. These county level numbers are aggregated upward to get a state average yield, harvested acres, and total wheat production. Although this estimate is very preliminary with wide confidence intervals, there are clear indications that production will be greatly diminished this year. The preliminary analysis developed here estimates a state average wheat yield of **36** bu/ac (confidence interval from 27 to 45 bu/ac), harvested wheat acres of **6.7** million acres (confidence interval from 5.9 to 7.3 million acres) and total wheat production of **241** million bu (confidence interval from 162 to 331 million bu).

Introduction

One glance at the U.S. Drought Monitor website or a drive through southwest Kansas would confirm that 2023 is starting off as a very dry year. As shown in Figure 1 (copied from https://droughtmonitor.unl.edu/DmData/TimeSeries.aspx), there have been very few years since 2000 where it is as dry as it is now. The only comparable year would be the end of 2012 into 2013.

Most farmers would agree that wheat prospects this year are poor based on the current soil moisture conditions. The question that farmers, lenders, and others in agriculture are asking though is what can Kansas expect for wheat production this year. Last year, Ibendahl estimated wheat yields and production on a regular basis throughout the growing season using the USDA estimates of crop conditions. These USDA estimates don't start on a regular basis until April though. Although it is still February, this paper estimates wheat yields, wheat harvested acres, and total wheat production both on a county level basis and then on a state level using the county level drought data from the U.S. Drought Monitor site. This data is available since 2000 on a weekly and county level basis allowing a yield prediction model to be developed much sooner than using the USDA crop condition indexes.

Data

The model developed here follows a similar procedure that Ibendahl used to estimate wheat yields based on the USDA crop conditions report. Instead of the growing conditions report, the Drought Severity and Coverage Index (DSCI) is used to estimate wheat yields. The DSCI (Akyuz) shares many similarities to the Crop Condition Index (CCI) (Bain and Fortenbery). Where the CCIndex weights the best condition with the most points, the DSCI weights the worst condition with the most points.

The U.S. Drought Monitor labels droughts by the level of severity. There are 5 levels of drought ranging from D0 (least severe) to D4 (most severe). The DSCI is a computed by the formula:

$$
\begin{aligned}
DSCI = &(\%\text{ acreage in D0}) * 1\\
&(\%\text{ acreage in D1}) * 2\\
&(\%\text{ acreage in D2}) * 3\\
&(\%\text{ acreage in D3}) * 4\\
&(\%\text{ acreage in D4}) * 5
\end{aligned}
$$

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The index ranges from [0, 500]. An index value of 500 corresponds to 100 percent of the crop acreage in the most extreme drought (D4), and a value of 0 indicates 100 percent of the crop acreage is not in any drought state. The U.S. Drought Monitor computes these values for various sized areas including at the county level. The site has weekly data back to the year 2000.

Model

The model used in this paper first computes the trend line yield on a county basis from 2000 to 2022. Most counties have a small positive trend line increase in yields. Next, the deviation from trend line is calculated for each year. This deviation from trend is what the DSCI is used to estimate.

A linear regression model is used to estimate the deviation from trend for a specific week using the data from 2000 to 2022. There is a separate regression model for each county with adequate data. The regression model is unique to a specific week. For this first paper in the yield prediction series, the lastest DSCI report for 2023 is week 8. To estimate the linear model, the DSCI data is filtered to provide only the historical week 8 DSCI numbers and these are used as the independent variable to predict the final yield. Once the linear model is developed at the county level, the DSCI reading for 2023 and week 8 is plugged into the equation to estimate the deviation from trend for this year's county yield.

Currently only the state planted acres for 2023 wheat are available. Also, not all counties have yield and acreage numbers available from last year. Because of some missing data, the counties that do have data available have to be scaled upward to match the state planted acres. Most county data is available so the scaling factor is only 1.21. The assumption is also made that the missing county data has equivalent yields to the counties used in the analysis.

Harvested acres are also important to the state production calculation. The harvested acres are estimated using the same procedure as the yield. In the acre calculation, the dependent variable is the percent of acres harvested.

Results

The county level results are shown in Tables 1 to 5. These are all the counties that had reported wheat yields in 2022 and these 2022 acreage numbers are then scaled to match the USDA reported planted wheat acres for 2023.

The second column in each of the tables is the trend line yield. This is the expected yield for a county in a "normal" year. The next three columns are the predicted yields based on the linear model using the DSCI to predict the yield deviation for this year. The yield deviation from the linear model is subtracted from the trend yield to get the predicted yields shown. While the most likely yield column is the point estimate of the model, the upper and lower range values should not be ignored. At this point, there is a wide range of yields that could occur and the confidence interval reflects this uncertainty.

The final column is the r-squared value and it tells how well the linear regression model fits the yield data. Values can range from -1 to 1 with a 0 value indicating the model doesn't predict yields at all. As these tables show, there is a wide variation in how well county level data works. While some counties show the model has no explanatory power, there are other counties with a strong fit. ***Those counties with an r-squared value close to zero will show a predicted yield close to trend line in most cases. In these counties more attention should be focused on the possible yield range.***

Although not shown in the tables, the r-squared values for predicted acres are all very low indicating the difficulty in forecasting final wheat acres.

The county level results are weighted by the number of wheat acres in the county last year and scaled upward to match the 2023 state planted wheat acres. The week 8 state results show an expected yield of 36.0 bu/ac with a possible range from 27.1 bu/ac to 45.3 bu/ac. The expected harvested wheat acres are 6.71 million acres with a possible range from 5.98 million acres to 7.30 million acres. The estimated wheat production for Kansas is 242 million bushels with a range from 162 million bushels to 331 million bushels.

Discussion

These are very preliminary results. However future weeks should show an improvement in the model. Once the USDA starts producing crop condition reports on a regular basis in April, this crop condition reports will also be used to forecast yields. The intention is to produce an estimate of wheat yields using both crop conditions and the drought index. While the drought index has an advantage of more detailed data down to the county level, it also has no way to indicate when there is excess moisture available. In other words, the drought index only shows moisture deficit levels and not excess moisture levels.

While this report currently indicates a poor wheat year, the wide confidence intervals indicate these predictions could improve with timely rains. It is still winter after all. Because the model had difficulty predicting harvested acres, this is probably the aspect of wheat production that could change the most between now and harvest. The poorest quality wheat is more likely to be abandoned which would help improve the state average wheat yield but at the expense of lowering harvested acres. Because there have been so few years with the dry start Kansas is currently experiencing, the model may not have provided a wide enough confidence interval on the low end of harvested acres.

References

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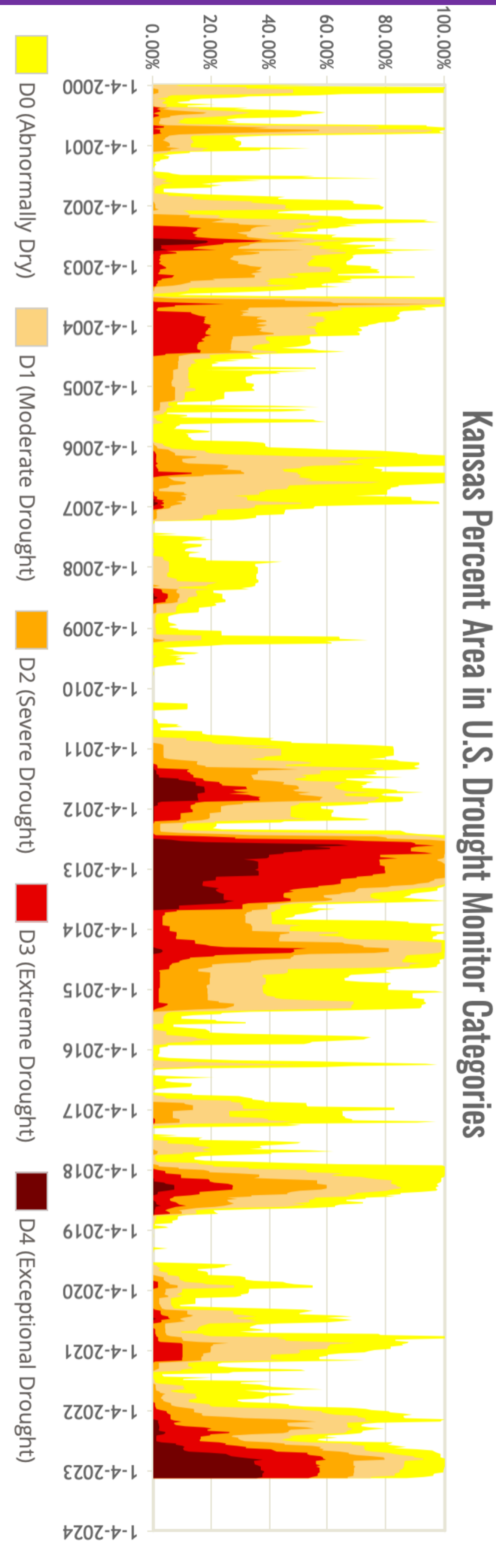

Figure 1. Drought Conditions in Kansas Since 2000 (source: droughtmonitor.unl.edu)

Table 1. Predicted County Yields for Wheat: Allen to Decatur Counties

Predicted County Yields

week - 8

County	Trend Yield	Predicted Yields: Lower Bounds	Predicted Yields: Most Likely Yield	Predicted Yields: Upper Bounds	R squared
ALLEN	48.7	38.4	50.0	61.5	−0.06
ANDERSON	43.7	39.7	44.0	48.3	0.12
ATCHISON	45.1	37.0	41.7	46.5	0.22
BARBER	34.3	7.2	21.1	34.9	0.17
BARTON	45.6	27.0	36.5	45.9	0.14
BOURBON	50.8	46.3	52.1	58.0	−0.02
BROWN	56.4	47.7	53.2	58.6	0.16
BUTLER	47.2	38.5	47.9	57.2	−0.05
CHASE	49.6	38.3	45.1	52.0	0.06
CHAUTAUQUA	43.9	35.6	48.9	62.1	−0.02
CHEROKEE	56.3	48.6	56.6	64.6	−0.05
CHEYENNE	53.5	41.2	46.4	51.6	0.45
CLARK	42.5	15.3	22.8	30.3	0.62
CLAY	48.1	44.2	48.2	52.3	−0.05
CLOUD	44.8	41.0	44.9	48.8	0.00
COFFEY	44.3	41.8	47.5	53.2	0.08
COMANCHE	33.4	4.8	15.5	26.2	0.38
COWLEY	41.9	25.2	39.1	53.1	−0.04
CRAWFORD	54.1	39.9	53.5	67.1	−0.06
DECATUR	50.2	30.7	39.0	47.2	0.33

Table 2. Predicted County Yields for Wheat: Dickinson to Harvey Counties

Predicted County Yields

week - 8

County	Trend Yield	Predicted Yields: Lower Bounds	Predicted Yields: Most Likely Yield	Predicted Yields: Upper Bounds	R squared
DICKINSON	48.9	44.2	49.5	54.9	−0.04
DONIPHAN	55.5	30.9	48.0	65.2	0.14
DOUGLAS	42.3	35.1	39.2	43.2	0.24
EDWARDS	45.9	22.7	32.4	42.2	0.28
ELK	49.6	34.6	49.5	64.4	−0.06
ELLIS	42.7	28.3	37.0	45.7	0.06
ELLSWORTH	43.4	27.2	38.4	49.6	0.00
FINNEY	41.2	10.6	23.3	36.0	0.34
FORD	49.1	21.2	31.2	41.1	0.45
FRANKLIN	45.7	39.5	44.9	50.2	−0.04
GEARY	47.8	41.2	46.8	52.4	−0.03
GOVE	49.0	24.6	37.0	49.5	0.15
GRAHAM	48.3	31.2	44.7	58.3	−0.04
GRANT	39.4	17.6	23.5	29.4	0.65
GRAY	49.7	18.4	31.5	44.5	0.30
GREELEY	42.3	20.4	28.1	35.8	0.47
GREENWOOD	48.8	38.9	49.4	60.0	−0.05
HAMILTON	35.2	5.8	15.3	24.8	0.52
HARPER	34.1	9.0	19.9	30.8	0.26
HARVEY	45.6	33.9	44.1	54.2	−0.04

Table 3. Predicted County Yields for Wheat: Haskell to Meade Counties

Predicted County Yields

week - 8

County	Trend Yield	Predicted Yields: Lower Bounds	Predicted Yields: Most Likely Yield	Predicted Yields: Upper Bounds	R squared
HASKELL	43.4	14.7	28.1	41.4	0.27
HODGEMAN	44.6	14.2	27.1	40.0	0.32
JACKSON	42.5	35.3	40.2	45.0	0.08
JEFFERSON	43.5	34.7	40.5	46.2	0.13
JEWELL	42.3	38.7	43.2	47.7	−0.03
JOHNSON	53.5	44.1	50.2	56.3	0.15
KEARNY	40.1	12.2	22.7	33.2	0.41
KINGMAN	40.0	19.5	32.3	45.1	0.04
KIOWA	44.6	13.5	23.1	32.7	0.57
LABETTE	44.9	39.7	49.7	59.7	0.01
LANE	49.6	9.7	24.7	39.8	0.40
LEAVENWORTH	49.1	43.8	47.0	50.2	0.20
LINCOLN	38.3	33.2	37.7	42.3	−0.02
LINN	43.8	36.8	42.5	48.2	−0.02
LOGAN	49.5	28.1	39.1	50.0	0.19
LYON	42.2	38.7	44.4	50.0	0.02
MCPHERSON	48.8	37.3	44.8	52.4	0.03
MARION	46.3	39.1	44.8	50.5	−0.02
MARSHALL	47.0	43.1	46.7	50.2	0.28
MEADE	46.1	18.2	30.5	42.8	0.32

Table 4. Predicted County Yields for Wheat: Miami to Rooks Counties

Predicted County Yields
week - 8

County	Trend Yield	Predicted Yields: Lower Bounds	Predicted Yields: Most Likely Yield	Predicted Yields: Upper Bounds	R squared
MIAMI	59.8	49.0	54.8	60.5	0.31
MITCHELL	49.9	46.5	49.9	53.3	−0.05
MONTGOMERY	47.1	45.2	53.2	61.1	0.10
MORRIS	45.5	41.5	45.7	49.8	−0.04
MORTON	31.5	7.9	16.1	24.4	0.46
NEMAHA	54.4	47.3	52.0	56.6	0.34
NEOSHO	47.1	37.5	51.8	66.1	−0.02
NESS	45.2	14.8	28.1	41.4	0.26
NORTON	36.1	20.4	26.9	33.3	0.40
OSAGE	48.4	44.3	48.3	52.3	0.02
OSBORNE	41.2	34.8	40.4	46.1	−0.05
OTTAWA	42.5	38.7	42.4	46.2	−0.05
PAWNEE	48.0	21.7	32.7	43.8	0.27
PHILLIPS	41.7	32.9	38.3	43.7	0.13
POTTAWATOMIE	49.6	40.1	45.0	49.9	0.30
PRATT	43.8	18.8	31.0	43.2	0.19
RAWLINS	57.0	41.8	48.4	54.9	0.39
RENO	42.3	26.6	38.0	49.5	−0.02
REPUBLIC	46.9	43.4	47.1	50.8	0.03
RICE	49.5	28.8	42.9	56.9	0.00
RILEY	43.1	38.1	41.9	45.8	0.11
ROOKS	48.1	40.7	46.7	52.6	−0.03

Table 5. Predicted County Yields for Wheat: Russell to Woodson Counties

Predicted County Yields

week - 8

		Predicted Yields			
County	Trend Yield	Lower Bounds	Most Likely Yield	Upper Bounds	R squared
RUSSELL	46.4	33.5	44.2	54.9	−0.04
SALINE	43.3	39.2	43.3	47.3	0.00
SCOTT	40.8	17.2	28.4	39.6	0.24
SEDGWICK	42.8	26.6	37.4	48.1	0.01
SEWARD	46.7	20.9	29.5	38.2	0.48
SHAWNEE	46.1	37.8	41.3	44.8	0.50
SHERIDAN	56.8	31.0	46.2	61.3	0.10
SHERMAN	51.7	39.5	45.2	50.9	0.31
SMITH	46.2	40.3	45.2	50.0	−0.02
STAFFORD	38.8	17.3	28.5	39.7	0.16
STANTON	41.7	10.5	25.2	40.0	0.28
STEVENS	40.5	21.3	26.8	32.3	0.61
SUMNER	40.3	22.0	33.8	45.7	0.02
THOMAS	45.3	26.1	36.9	47.7	0.15
TREGO	41.4	18.7	33.0	47.3	0.05
WABAUNSEE	43.5	37.2	42.1	47.0	0.08
WALLACE	45.0	35.8	41.9	48.0	0.06
WASHINGTON	45.7	42.1	45.6	49.1	0.26
WICHITA	48.8	22.4	31.9	41.4	0.42
WILSON	54.0	44.0	58.2	72.4	−0.03
WOODSON	43.8	25.9	47.4	68.9	−0.05