Modeling of Grain Sorghum Indirect Land Use Change

Introduction

EPA is currently using the FAPRI model from Iowa State University to model the indirect land use change (ILUC) from grain sorghum. This modeling is being done as a part of the pathway determination of grain sorghum in the supplemental rule to RFS2.

While the last EPA model run of FAPRI is not available to the National Sorghum Producers at this time, the model references in this paper refer to a model run that FAPRI has referenced as "arbitrage." The arbitrage model featured the same price changes in corn and grain sorghum at the US farm gate level. The last EPA model run further developed these arbitrage changes, and from graphs shared by EPA, NSP believes that these model results did not change dramatically from the arbitrage model. Again, the remainder of this paper focuses on the FAPRI arbitrage model and its calculation of ILUC from grain sorghum.

Grain sorghum ILUC calculations

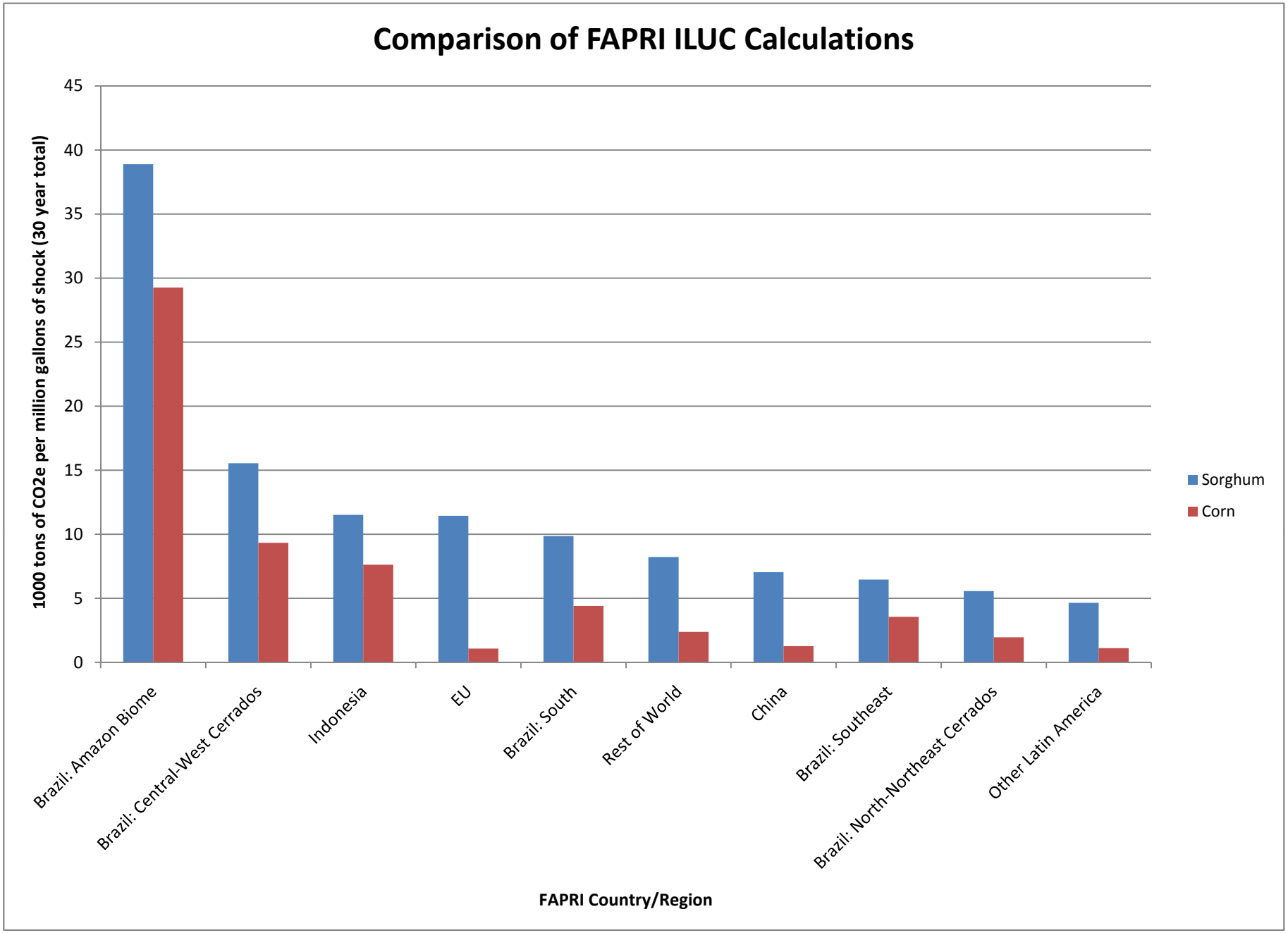
The key component in the calculation of ILUC from grain sorghum is an increase in corn acreage in the US to compensate for the loss of feed and exports from grain sorghum which is being made into ethanol. These increased corn acres come mainly at the loss of soybean acres which result in a loss of soybean exports. This loss of soybean exports then translates into increased soybean acres in Brazil which result in ILUC. On a much smaller scale, this also happens with wheat in the European Union. As wheat acres decrease in the US, wheat exports decline, and the European Union increases wheat acres which results in ILUC. Graph 1 shows the ILUC calculations for corn (RFS2 final rule) and sorghum (arbitrage) in the ten largest sorghum ILUC FAPRI country/regions. [Sources of data: Corn ILUC from EPA docket workbook "EPA-HQ-OAR-2005-0161-3173-6.xls" (hereafter referred to as "6f") – sheet "LUC_2022;" corn production shock from same sheet, cell B74 divided by 76,000 to convert to millions of gallons; sorghum ILUC is estimated based on workbook "2011 Sorghum Only Case (Scenario 2) FINAL 02-03-2011.xls" (hereafter referred to as "Arbitrage"); sorghum production shock assumption is 200 million gallons.]

Although the ILUC is based on actions in other countries, it is important to understand that FAPRI first solves for a domestic solution. If this domestic solution is not correct, then any international reaction will also be incorrect as will be the resultant ILUC.

Furthermore, the ILUC for sorghum seems to come much more from changes in world trade than corn. Net changes in world trade in corn, sorghum, and barley account for 11.6% of the production shock in the corn model, while the net change in trade in the same three grains accounts for 32.3% of the production shock in the sorghum model. [Sources of data: Corn net trade change from EPA docket workbooks "EPA-HQ-OAR-2005-0161-3167.xls" (hereafter referred to as "FAPRI Corn") and "EPA-HQ-OAR-2005-0161-3166.xls" (hereafter referred to as "Control"), sheet "Grains2009" with all references to column O. Sorghum net trade change from

“Arbitrage,” sheet “Grains” and the “Control” workbook, sheet “Grains2009” with all references to column O.]

Graph 1: Comparison of FAPRI ILUC calculations



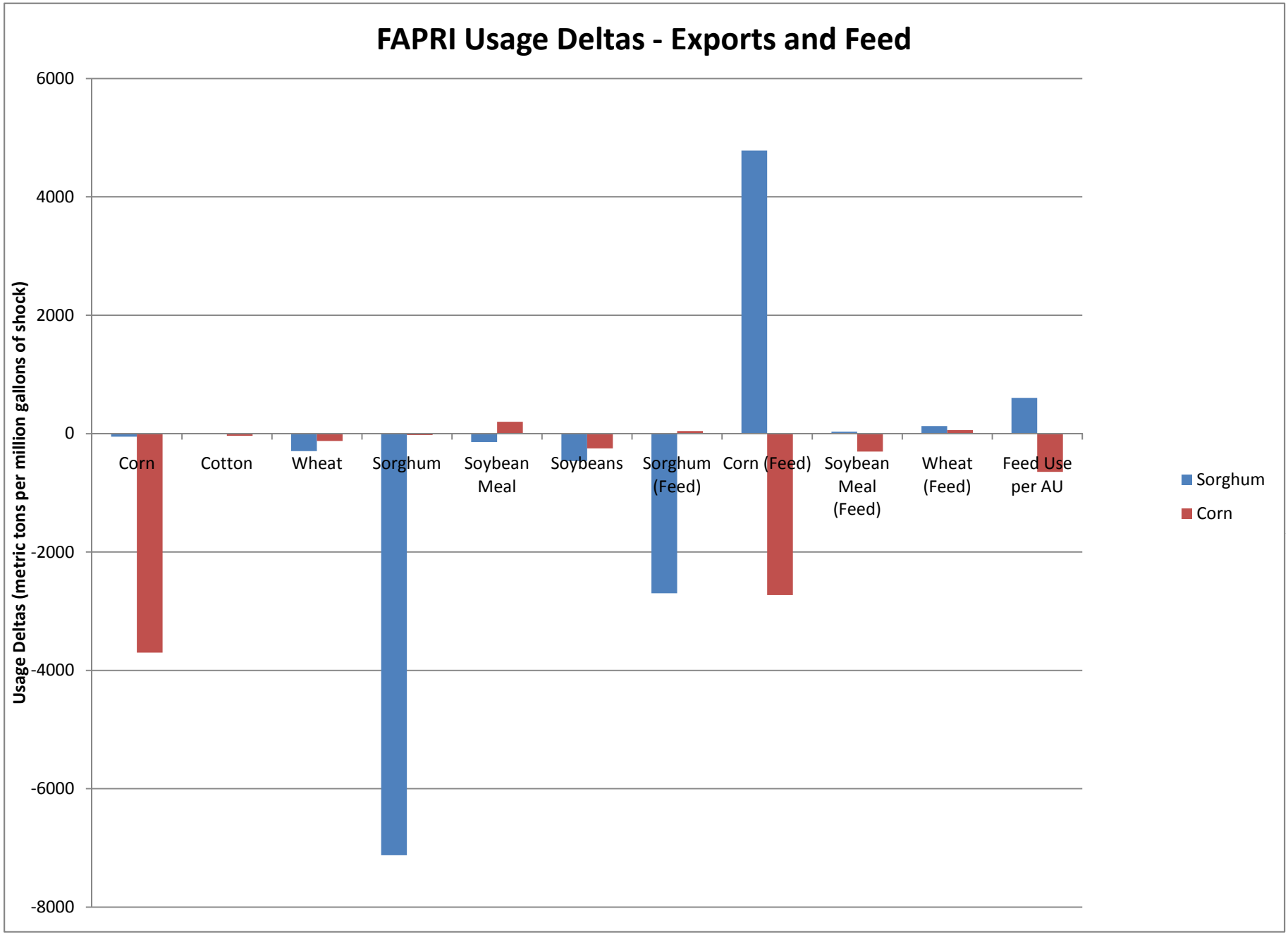
Domestic Feed Use

Domestic feed use is an important component in the usage calculations of all US grains. This use, combined with export and biofuels production, is the largest component of most grain usage. Graph 2 examines the change in usage between the corn (RFS2 final) and sorghum (arbitrage) for both export and domestic feed use. As expected the, corn exports and feed use decrease substantially in the corn model as it is being used to produce ethanol. While sorghum and wheat feed use increase some in the corn model, the net effect is lower feed per animal unit (AU). The total feed per AU includes corn, sorghum, soybean meal, wheat, oats, and barley (oat and barley feed use changes are not displayed due to very minor changes in both corn and sorghum models). [Sources of data: Workbooks "FAPRI Corn," "Control," and "Arbitrage" with references to the US net trade (exports) and feed use under the heading of "US Supply and Utilization" in the respectively named sheets. Numbers for corn, sorghum, corn (feed), and sorghum (feed) are in sheet "Grains2009" or "Grains," with soybeans, soybean meal, and soybean meal (feed) in sheet "Oilseeds2009" or "Oilseeds." AU numbers calculated from "US Supply and Utilization" headings from sheets "Livestock2009," "Livestock," "Dairy2009," and "Dairy." All references are from column O. Poultry and turkey numbers converted from 1000mts of production to millions of head based on factors published by EPA in docket workbook "EPA-HQ-OAR-2005-0161-3153-1.xls" (hereafter referred to as "1a"), sheet "Misc_Cnvrsn_Fctrs."]

However, in the sorghum model, the decrease in exports and feed use are again expected based on increased ethanol production. However, the very large increase in corn feed use in the sorghum model is not expected. In fact, the increase in all other feed use is 184% of the sorghum feed use decrease. Although AUs decrease in both the corn and sorghum models, the feed use per AU increases in the sorghum model while it decreases in the corn model. This would imply that sorghum's feed value is considerably more than corn when in fact they are very similar. [Sources of data: All other feed use is the combination of corn, barley, oats, wheat, and soybean meal deltas from the workbooks and sheets mentioned in the previous paragraph.]

If the feed use per AU decreased in the sorghum model as in the corn model, then this excess corn would not be grown. If it is not grown, then soybean acres would not be reduced, soybean exports would not be reduced, and consequently acres would not increase in Brazil resulting in a lower ILUC for sorghum.

Graph 2: FAPRI usage deltas for both exports and feed

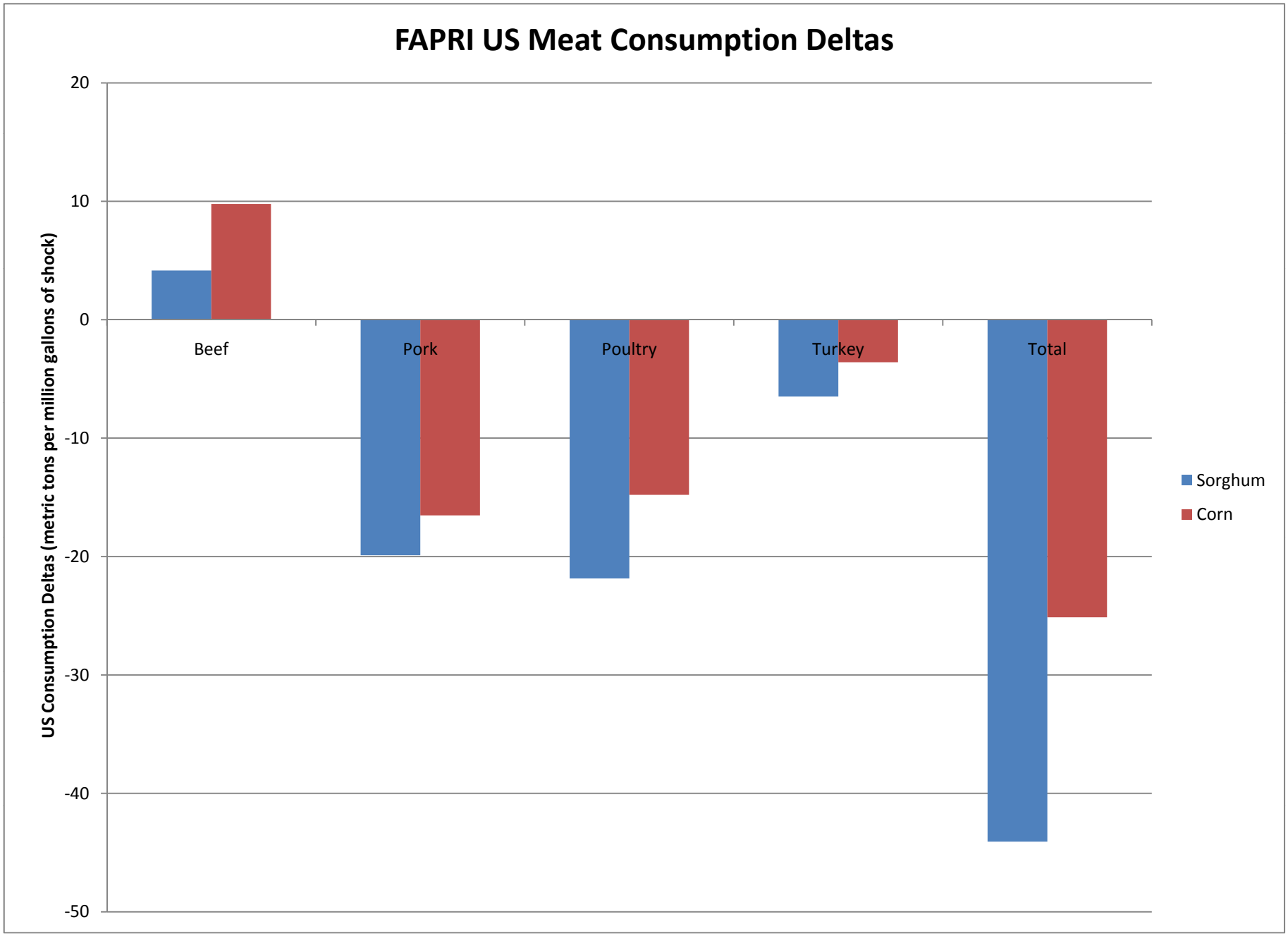


US Meat and Dairy Consumption

Decreases in US meat consumption are the direct causes of the fewer AU as discussed in the previous section. However, the consumption destruction is much greater in the sorghum model compared to the corn model. Measured as metric tons per million gallons of production shock, the decline in total US meat consumption is 75% greater in the sorghum model compared to the corn model. Graph 3 demonstrates the consumption for the beef, pork, poultry, and turkey markets in both the sorghum and corn models. [Sources of data: Workbooks "FAPRI Corn," "Control," and "Arbitrage" with references to the heading "US Meat Supply and Utilization" in sheets "Livestock2009" or "Livestock" with all references to column O.]

In the sorghum model, dairy consumption and cow herd size are not affected (deltas are exactly zero). However, in the corn model, all dairy consumption drops by 5.5 metric tons per million gallons of production shock. [Sources of data: Workbooks "FAPRI Corn," "Control," and "Arbitrage" with references to the heading "US Dairy Supply and Utilization" in sheets "Dairy2009" or "Dairy" with all references to column O. All dairy consumption is the total of fluid milk, butter, cheese, and nonfat dry milk consumption.]

Graph 3: FAPRI US meat consumption deltas



Distiller's Grains

In the FAPRI model, distiller's grains are allowed to substitute for grains and soybean meal in feed rations to account for their use in the feed industry. This inclusion lessens the impact of ethanol production by realizing the feed value of the co-product. The distiller's grains inclusion and feed value assumptions are based on distiller's grains from corn ethanol facilities with extraction or fractionation. The extraction and fractionation processes remove corn oil from the distiller's grains and that corn oil is subsequently used to produce biodiesel. On a per mass basis, these processes lower the energy content of the distiller's grains and increase the protein content.

Sorghum distiller's grains will not be processed in a facility with extraction or fractionation since these processes are not economically viable for sorghum and 92% of sorghum distiller's grains are sold wet. With full oil content in the distiller's grains, the sorghum distiller's grains will be higher in energy and lower in protein content on a per mass basis. This should allow for a higher inclusion rate in the rations and displace more corn or sorghum (unpublished data from a South Dakota State University study completed in the last year).

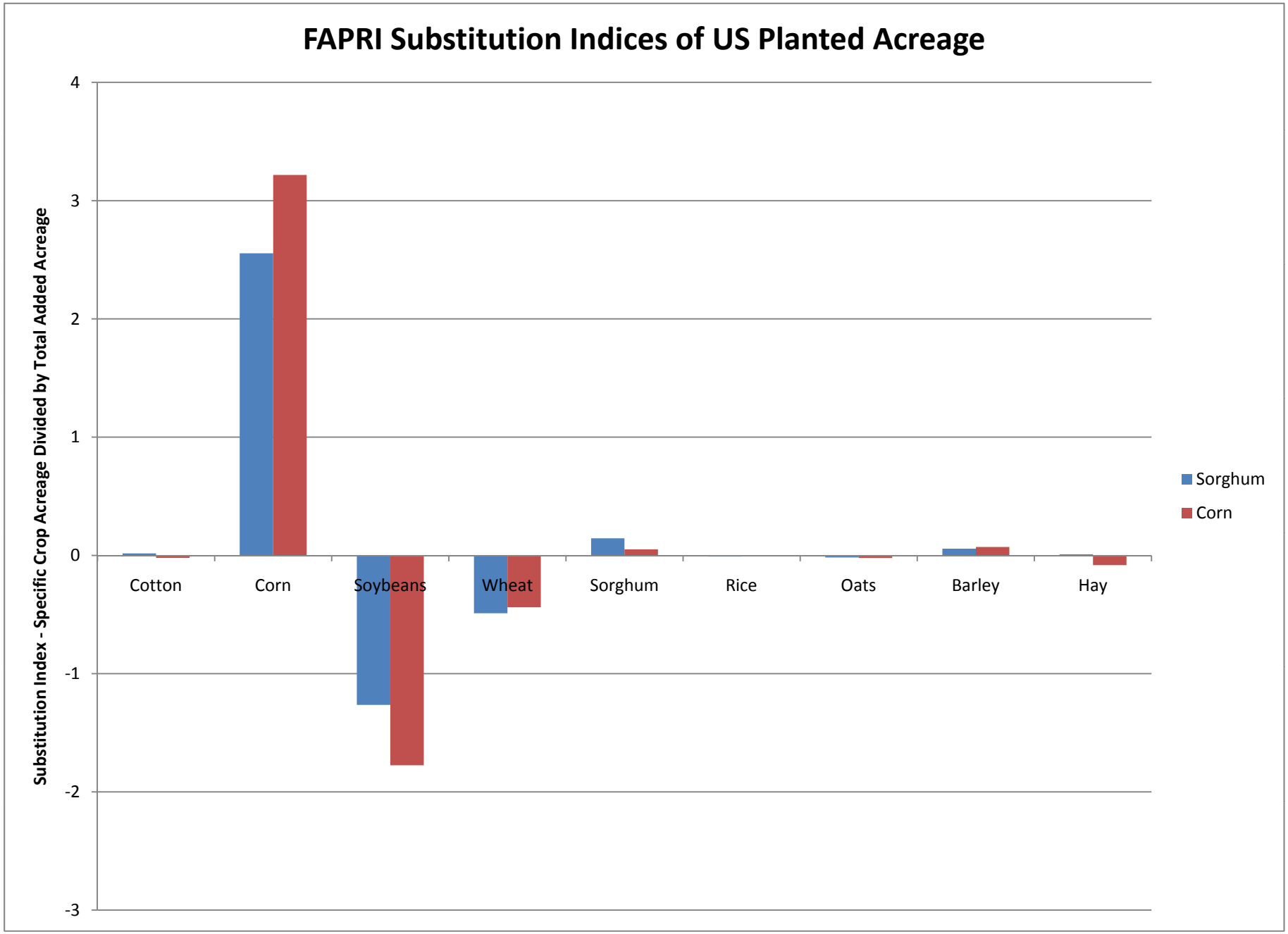
The displacement assumptions in the FAPRI model also need to allow for substitution of sorghum distiller's grains in rations for both corn and sorghum. Currently, the FAPRI model assumption only allows for sorghum distiller's grains to replace grain sorghum and not corn. Given the higher farm gate price of corn compared to sorghum and that livestock feeders' feed prices will be closer to the farm gate price than the Gulf price, it would make economic sense for the feeder to replace corn as it is the higher priced feed ingredient.

Substitution Indices

To account for the sensitivity of the FAPRI model to substitute planted acres between crops, a substitution index was calculated for the 8 main crops in the model as well as hay. The substitution index is the quotient of the specific crop acreage divided by the total added acreage. For example, if the FAPRI model for corn added 100,000 acres, but sorghum increased by 1,000 acres, then the substitution index for sorghum in the FAPRI corn model would be 0.01 (1,000/100,000).

Graph 4 displays the substitution indices for the 8 main crops as well as hay ground as calculated from corn and sorghum FAPRI models. The corn model is more aggressive in substituting acreage between crops than the sorghum model, especially in corn and soybeans. In the sorghum model, 397 acres are added for every million gallons of production shock. However, in the corn model which is much more aggressive in substituting acres, only 183 acres are added for every million gallons of production shock. Per million gallons of production shock, the sorghum model is adding over two acres for every acre added in the corn model. [Sources of data: Workbooks "FAPRI Corn," "Control," and "Arbitrage" with references to "Planted Area" under the appropriate crop heading in the sheets "US2009" or "US" with all references to column O. Total added acres are the sum of the acreage changes to the 8 main crops plus hay due to the production shock for corn or sorghum.]

Graph 4: FAPRI substitution indices of US planted acreage



The state level results reveal even more discrepancies between the corn and sorghum models. Map 1 displays four different crop acreages:

1. Total planted plus hay plus CRP – total planted plus hay plus CRP is a land category defined in the FAPRI output tables and includes all planted acreage, not just the crops featured in Graph 4.
2. Corn
3. Soybeans
4. Wheat

The maps all show very small deltas between the sorghum and corn FAPRI substitution indices for these crops. As mentioned in the previous section, the corn model is more aggressive in substituting planted acres, but the state maps show that between the corn and sorghum models the delta between the substitution indices for each state is very small for these crop acreages.

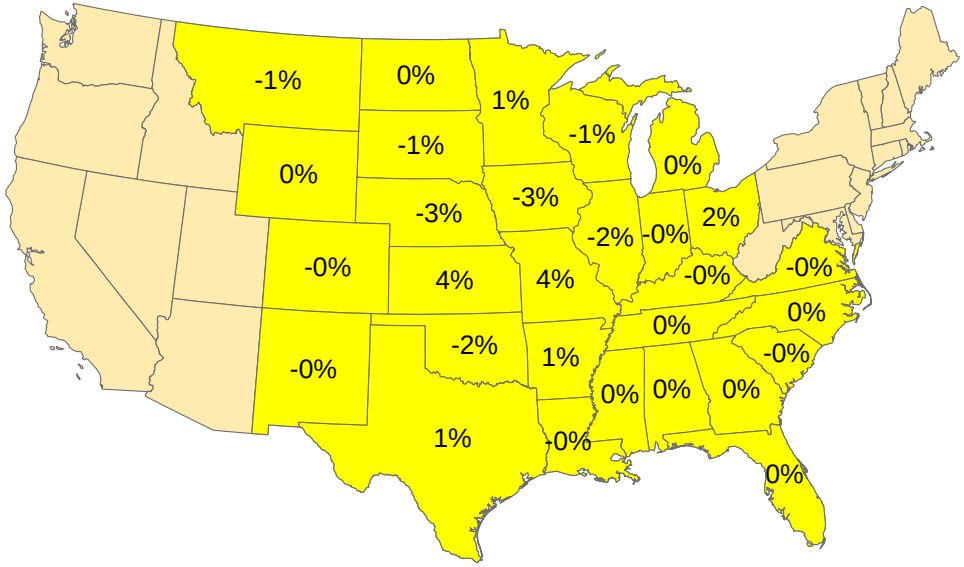
However, Map 2 shows the state deltas for sorghum. Notice that all but three states show the same range as Map 1 with very little differences in the state substitution indices. However, three states show much larger changes compared to the corn model.

Map 3 displays the state deltas for hay. Notice the huge variations between the corn and sorghum state substitution indices. The FAPRI model seems to be at a loss on how to model the hay acreage and its effect on sorghum in the sorghum model. [Sources of data: Workbooks “FAPRI Corn,” “Control,” and “Arbitrage” with references to column O in sheet “US Planted Area.” Selected states have acreages for each crop; however, Pennsylvania only has acreages for corn and soybeans and was not mapped.]

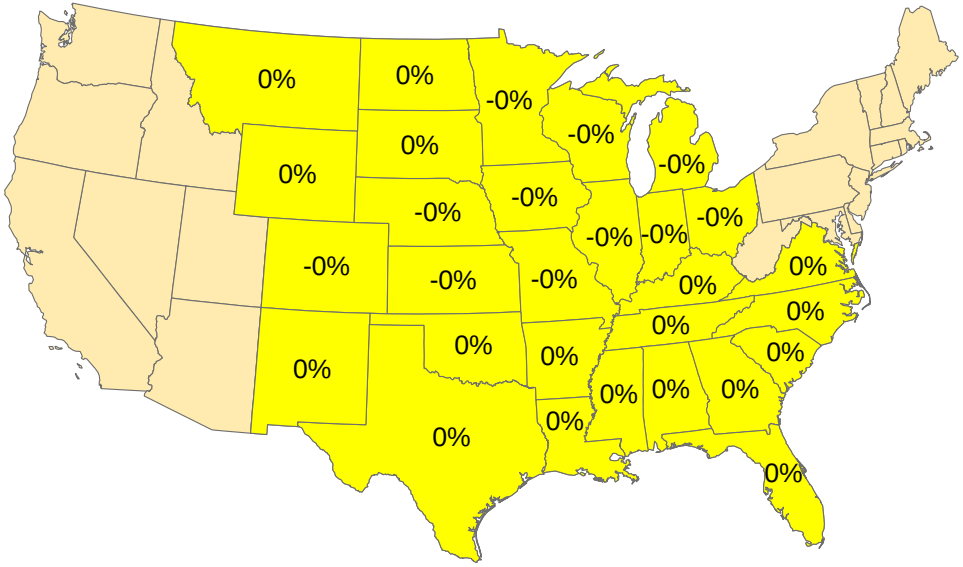
Map 1: FAPRI substitution index deltas for total planted + CRP + hay, corn, soybeans, and wheat

FAPRI Substitution Index Deltas (Sorghum - Corn)

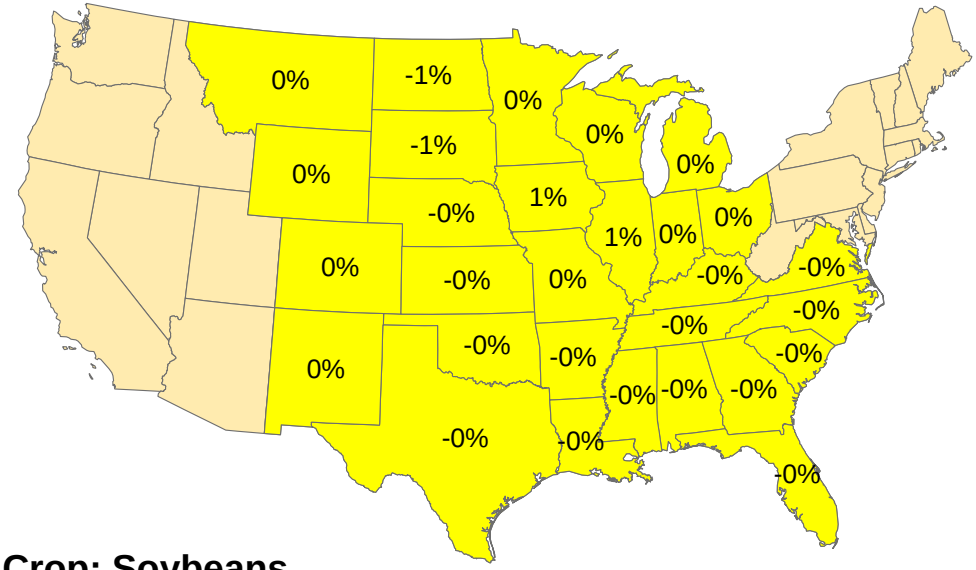
-10% - 7%



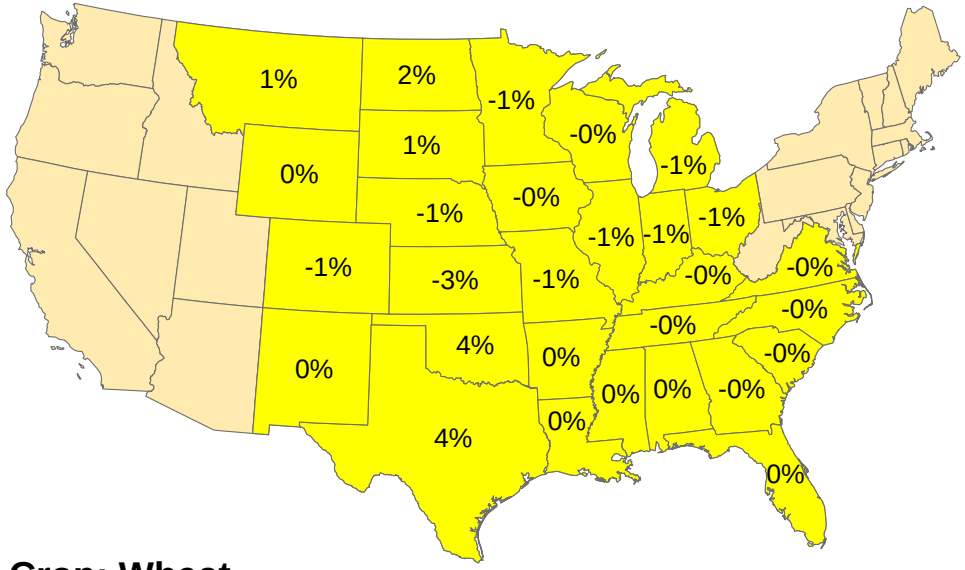
Crop: Total Planted + Hay + CRP



Crop: Corn



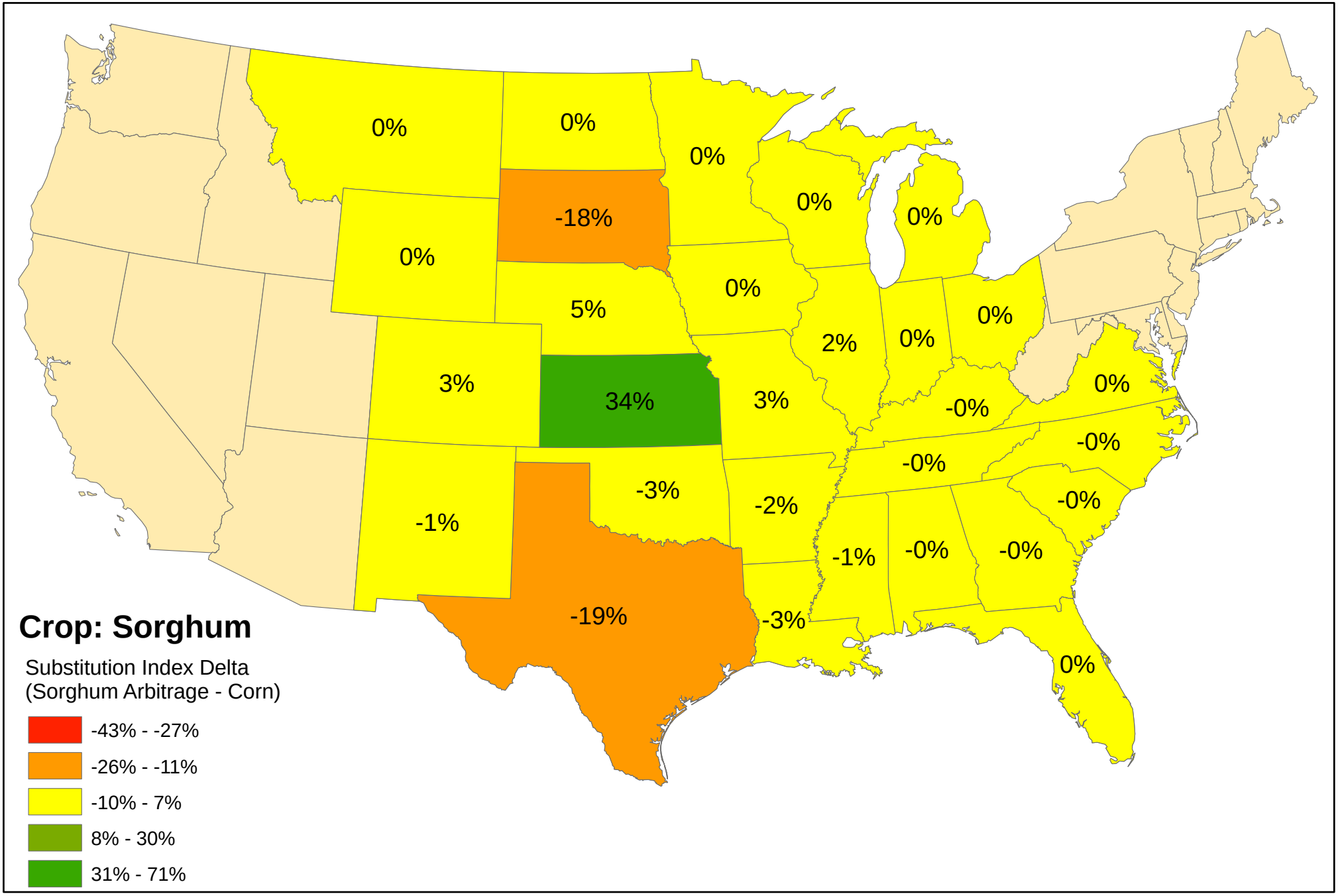
Crop: Soybeans

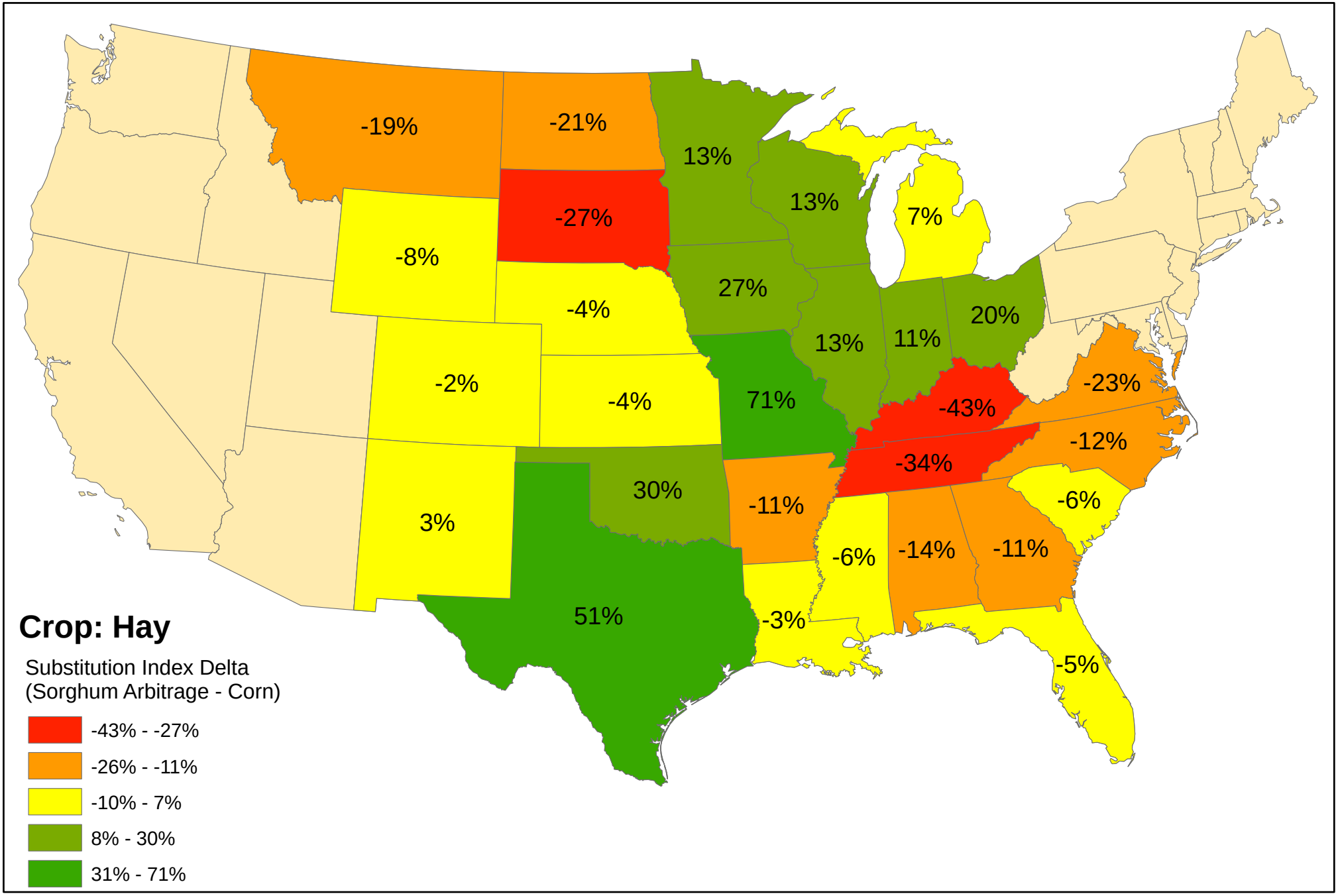


Crop: Wheat

Map 2: FAPRI substitution index delta for sorghum

FAPRI Substitution Index Delta (Sorghum - Corn)



Map 3: FAPRI substitution index delta for hay

FAPRI Substitution Index Delta (Sorghum - Corn)