Spatially Explicit Estimates of Crop Rotation Responses

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Overview

Crop transition models are estimated using high resolution data from the Cropland Data Layer. The response to price is allowed to vary across different soils types. Initial estimates indicate that there is substantial heterogeneity in acreage response to price and that the response tends to be larger in areas with lower runoff potential.

Data

Crops	Cropland Data Layer – NASS Illinois: 1999-2010 Iowa & Indiana: 2000-2010
Prices	Jan-March average price of new harvest futures contract – adjusted for loan deficiency payments
Unit of Analysis ("field" boundaries)	2007 Common Land Unit GIS data layer released by Farm Service Agency
Soils	SSURGO database - NRCS
April-May Precip	PRISM Climate Group

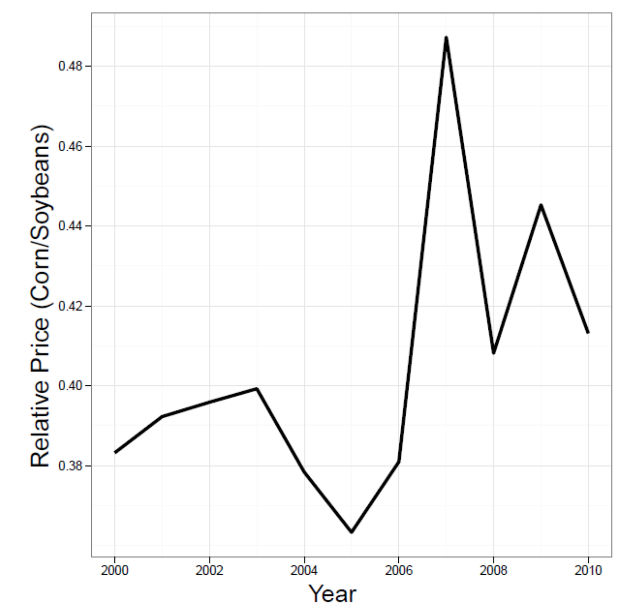
Methods

The Cropland Data Layer provides high resolution (less than 1 acre) crop data derived from satellite imagery. However, each pixel does not represent a separate decision since there are many pixels within each field. Pixels at field boundaries are also more likely to be misclassified. The Common Land Unit (CLU) boundaries are used to avoid such problems. We calculate the centroid of each CLU then a point is chosen that is slightly offset diagonally from the centroid. These points predominantly fall in the middle of "fields" and provide the unit of analysis for the empirical model. Soil and precipitation variables are also spatially merged at each of the points. There are about 850,000 points each year that are classified as either corn or soybeans.

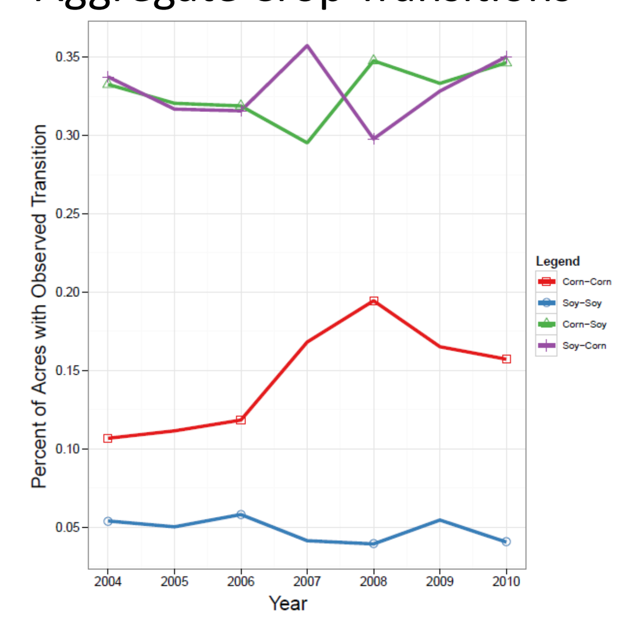
We estimate two Markov transition linear probability models: the probability of planting corn given corn was planted last year and given that soybeans were planted last year. The coefficients on corn and soybean prices are allowed to vary across different soil types because we hypothesize that differences in relative yields on different soils will lead to different price responses. The soil taxonomy from NRCS is used to identify soils that have similar characteristics. In addition, interaction terms with percent clay, percent silt, and slope are included in the model. Estimates from the transition models are used to calculate the probability of planting corn (unconditional of the previous crop) and the change in the probability of planting corn for a $1/bu increase in the price of corn, holding the price of soybeans constant for each point in our dataset, which is then mapped using the Common Land Unit GIS data layer.

Data Visualization

Relative Prices



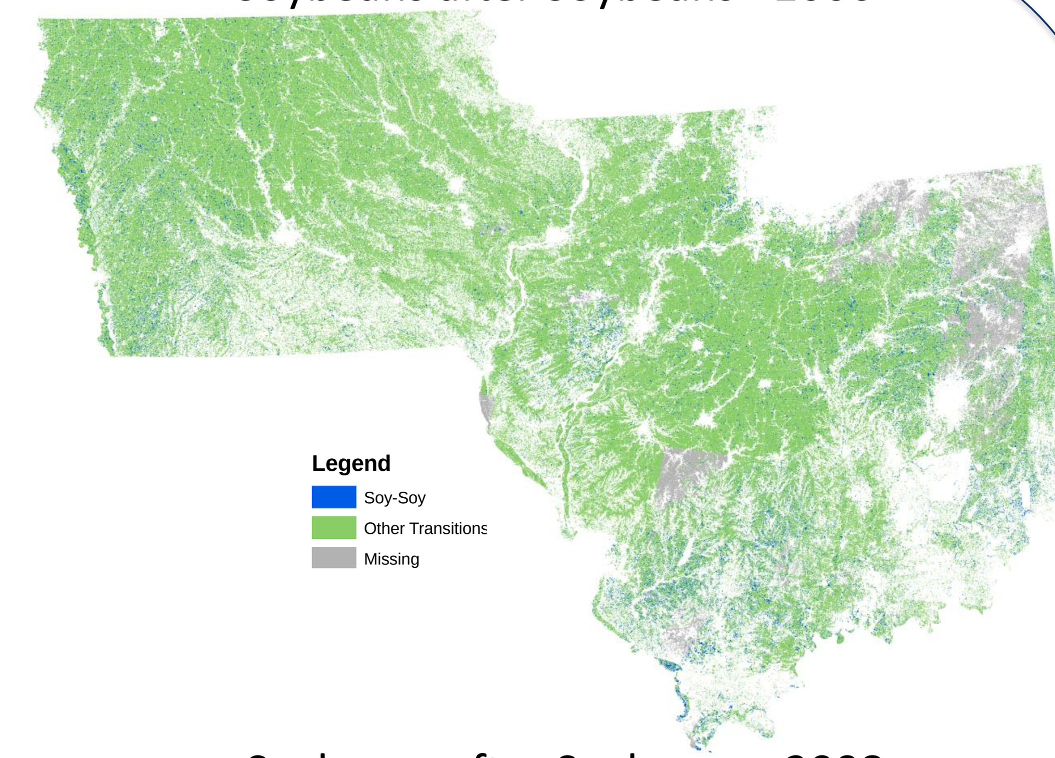
Aggregate Crop Transitions



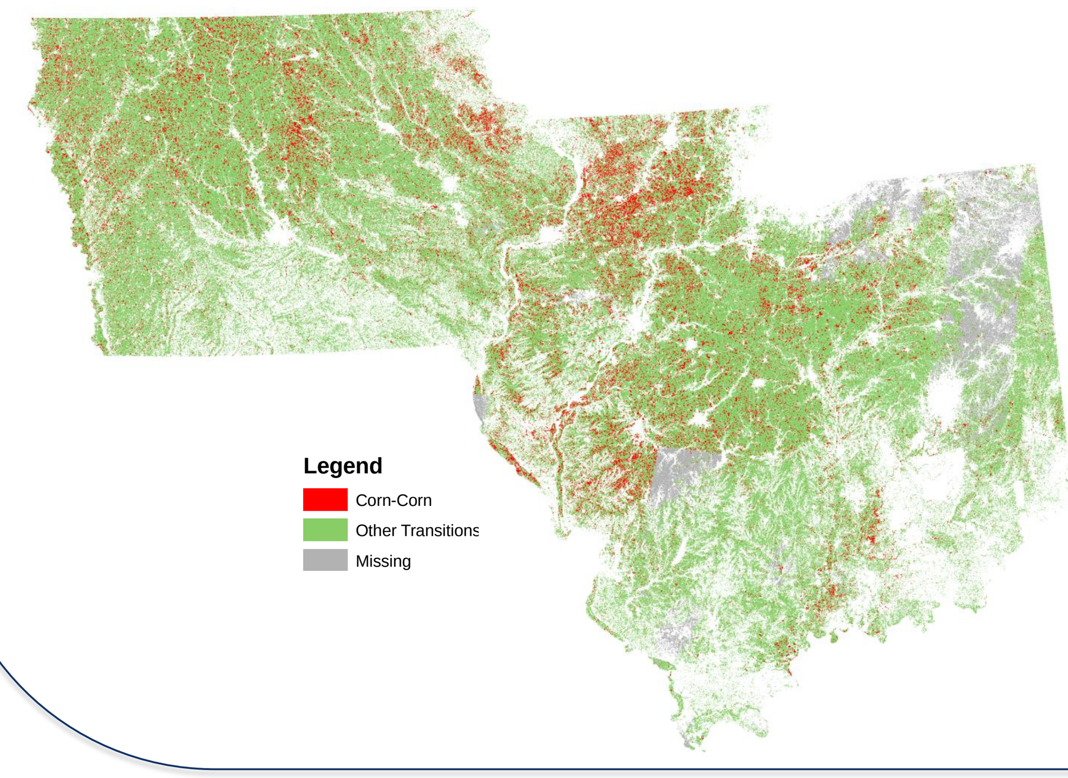
Although commodity prices as a whole peaked in 2008, the relative price of corn increased first and peaked in 2007. Although not shown, this led to a sharp increase in the acres planted to corn in 2007 in the Corn Belt, largely offset by a decrease in soybean acres. Acres that were corn after corn increased sharply in 2007 and then increased again in 2008, even though total corn acres decreased in 2008.

The four maps show the spatial distribution of crop transitions. It is clear from the maps that monoculture is spatially concentrated in certain locations and it appears that the price response has a spatial component as well.

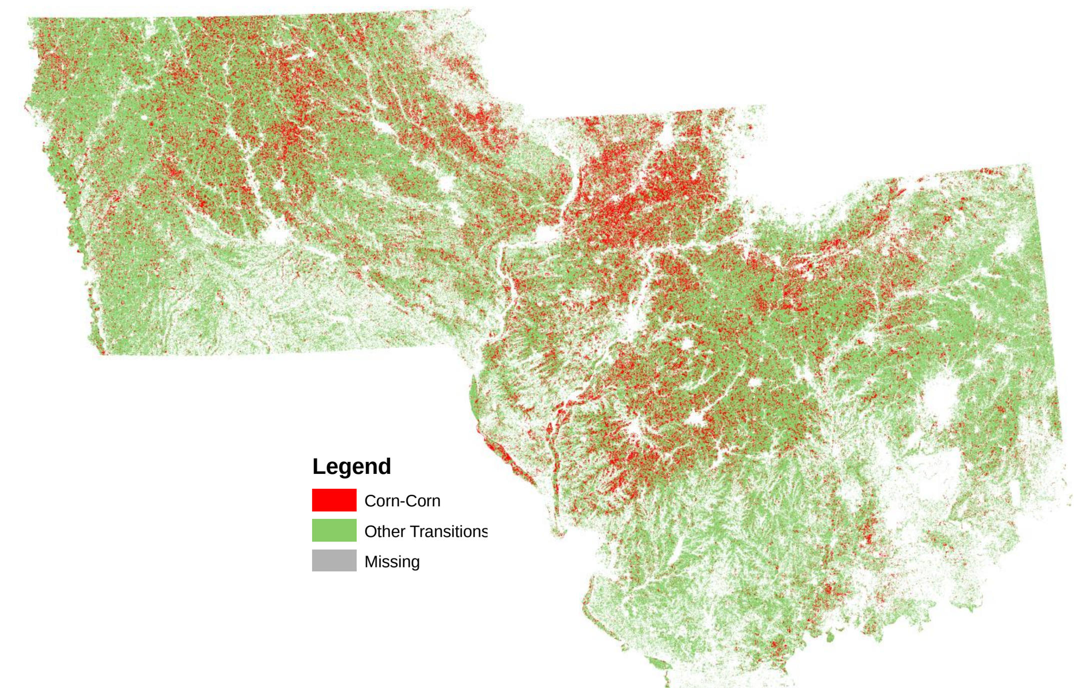
Soybeans after Soybeans - 2006



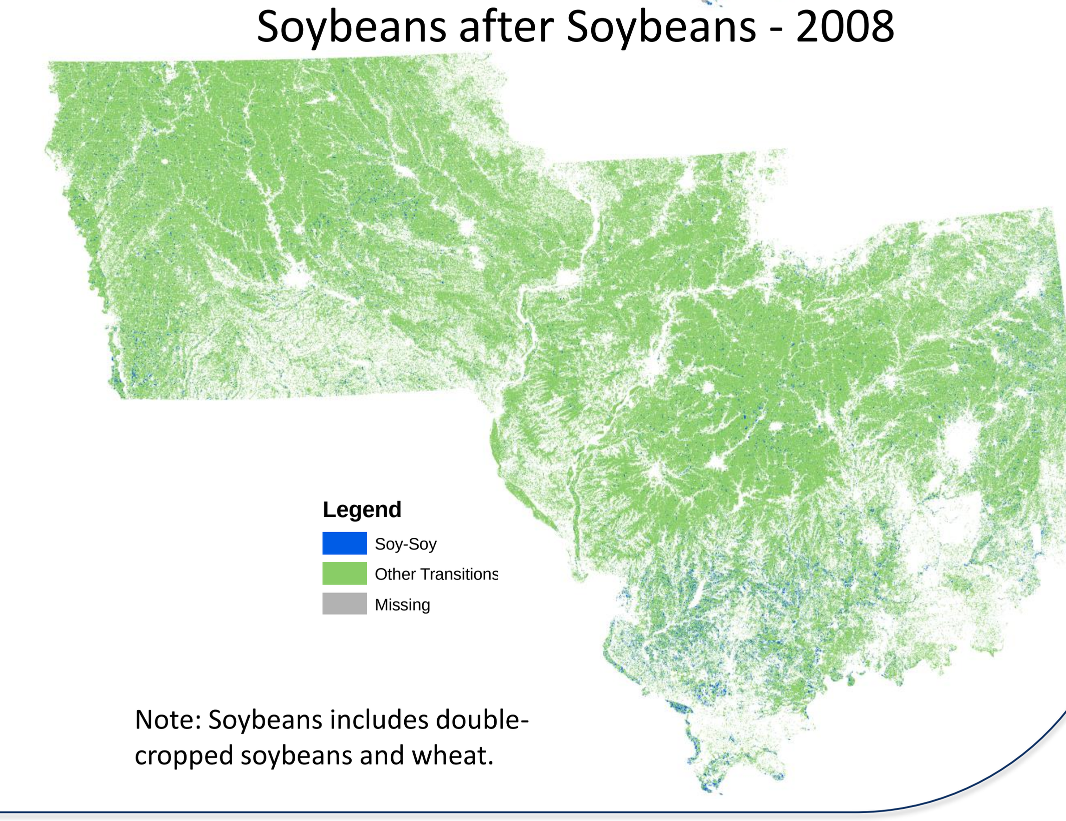
Corn after Corn - 2006



Corn after Corn - 2008



Soybeans after Soybeans - 2008

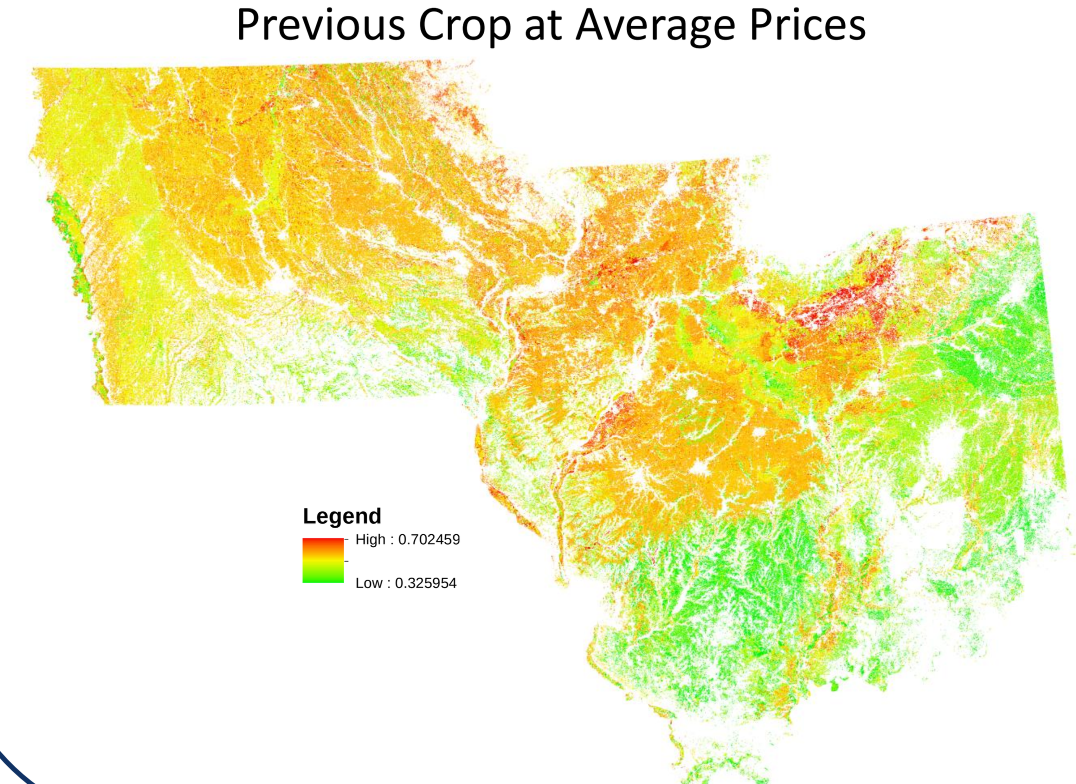


Note: Soybeans includes double-cropped soybeans and wheat.

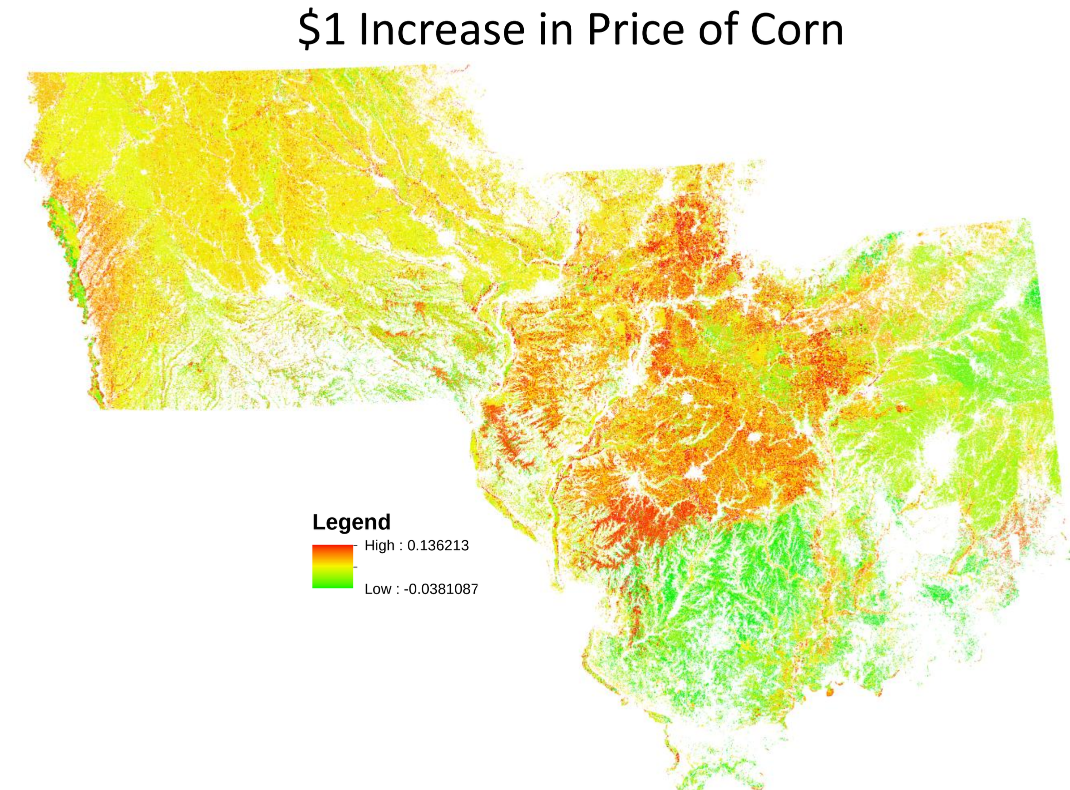
Results

The Markov transition probabilities are used to calculate the probability of planting corn in each CLU, unconditional of the previous crop (bottom left map). The change in the probability of planting corn given the previous crop was corn or soybeans is also calculated. Combining these estimates gives the average short-run change in the probability of planting corn for a change in the price of corn (bottom right map). As expected, we estimate a positive price response for nearly every CLU. The steady-state change in the probability of planting corn is smaller than the short-run effect, but is not reported here. Generally areas with a higher probability of planting corn also have a larger acreage response to price, although there appear to be deviations from this pattern.

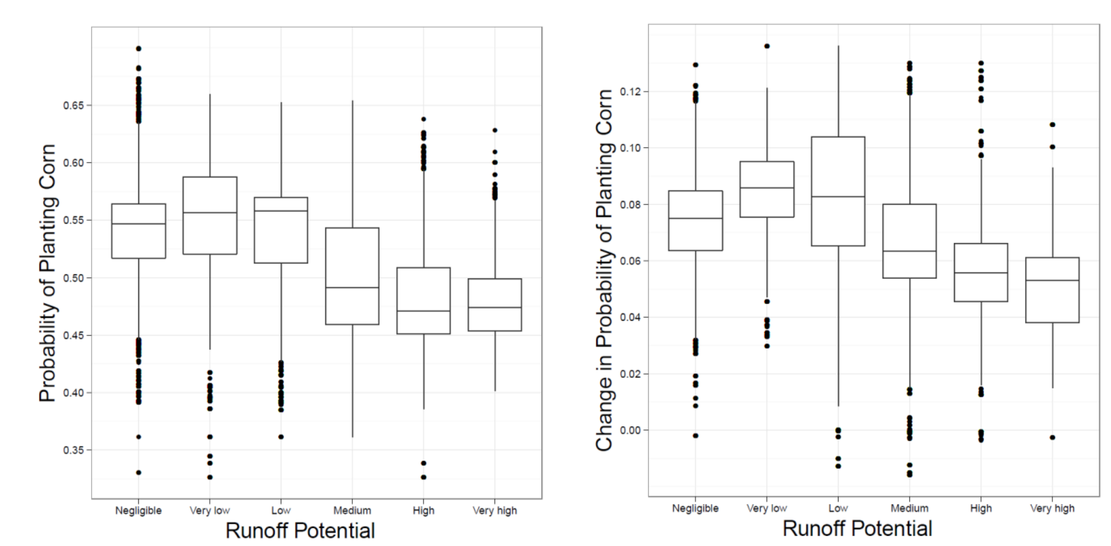
Probability of Planting Corn Unconditional of Previous Crop at Average Prices



Short-run Change in Probability of Planting Corn for $1 Increase in Price of Corn



Correlation of Corn Supply with Water Runoff Potential



The first graph indicates that corn production is more likely to occur on land that has a lower runoff potential. Furthermore, when the price of corn increases, the acreage response is larger in areas with a lower runoff potential. Future work will compare the supply parameters with other environmental indicators, but these initial results indicate that the effect of corn production on water quality will be biased if researchers assume corn supply is homogenous across space in the Corn Belt.