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Cropland Reflux: Trends In and Locations of Land Use Change in the Dakotas, 2007 to 2012 and 2012 to 2017

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Cropland Reflux: Trends in and locations of land use change in the Dakotas, 2007 to 2012 and 2012 to 2017

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Summary

This article analyzed land use conversion trends in South and North Dakota over the 2007-2012 and 2012-2017 periods using USDA NASS cropland data layer (CDL) data. Most grassland to cropland conversions occurred during the 2007-2012 period. In South Dakota, nearly 20% of grassland in 2007 was converted to cropland by 2012. During the 2012 to 2017 period, substantial reversion to grass occurred. Land use change trends in North Dakota were similar to those in South Dakota over the 2007-2017 time frame, with a high grassland to cropland conversion rate during 2007-2012 (19.90%) and a greatly curtailed conversion rate during 2012-2017 period (7.81%). To a large degree, changes in land conversion trends in the Dakotas between 2007-2012 and 2012-2017 can be attributed to changing crop prices. Yet due to the "hysteresis" phenomena, even though crop prices have been overall declining since 2012, grassland acres in the future are not likely to revert to the same level as 2007.

Introduction

Large tracts of land in South and North Dakota are marginal in the economic sense that their uses have changed several times since non-indigenous settlement. Annually planted crops and grass-based beef production activities have at times both been profitable land uses in the central and eastern portions of these states. Commencing about 2006, an expansion of cropland acres, largely corn and soybean, occurred in the region. Quite a few recent papers have analyzed the amount of cropland expansion at the expense of grassland during the 2006-2012 period (Wright and Wimberly 2013; Reitsma et al. 2014; Lark et al. 2015; Wimberly et al., 2017).

A confluence of forces likely propelled this change. Higher commodity prices were a primary factor (Wang et al. 2017), due to demand from both the biofuels sector and Asian markets. Meanwhile, commencing in the late 1990s several seed innovations were brought to market that reduced the need for labor and pest management inputs in corn and soybean cropping, and relaxed environmental constraints on cropping erosion-prone soils (Perry et al. 2016). In addition, seed treatment technologies reduced the cost of earlier planting while better cultivation systems allowed for more efficient use of a short growing season.

Between 2013 and 2017, partly in response to several good harvests, commodity prices declined markedly in the Northern Great Plains and throughout the world, placing pressure on crop producers everywhere but especially in marginal growing areas. This article aims to present and analyze USDA NASS cropland data (CDL data) on land use in South and North Dakota. By comparing CDL data for the Dakotas over the two periods 2007-2012 and 2012-2017, we hope

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to shed some light on what has happened to land use conversion as a result of recent commodity prices change.

Methodology

To study land use trend in the Dakotas, we used ArcGIS software to analyze CDL data that includes locations where land use has changed between 2007 and 2012, and between 2012 and 2017. CDL data allows us to trace the exact pixel, and so the precise map coordinates, where land use change has taken place. Reliability is not perfect as satellite-garnered data can be affected by atmospheric conditions and error can arise when processing signals. However, studies have shown data to be reliable in the aggregate and especially so for the major annual crops.

Since data for 2007 was based on a different pixel size than the data for 2012 and 2017, ArcGIS resampling technique was used to address this issue[2]. Areas that grow all type of cultivated crops including hay and alfalfa were classified as cropland, and areas that grow all types of grass such as pasture, rangeland and CRP land were classified as grassland. Raster calculation was then used to identify geographical locations of two types of land use conversions in South Dakota: 1) grassland conversion to cropland, and 2) cropland conversion to grassland.

Results

Table 1 reports the grassland and cropland acreages in South Dakota and North Dakota for 2007, 2012 and 2017. During 2007 and 2012 period, grassland loss was a serious issue for both states. This finding is consistent with conclusions in Reitsma et al. (2014), Wright and Wimberly (2013) and Decision Innovation Solutions (2013). When comparing South Dakota land use changes between 2012 and 2017, grassland acres showed a slight increase, while cropland acres slightly decreases, indicating a halt in grassland loss, at least temporarily. In North Dakota, however, grassland loss continues but at a curtailed rate.

Table 1: Grassland and cropland acreages in the Dakotas for 2007, 2012 and 2017

	Grassland acres			**Cropland acres**		
State	2007	2012	2017	2007	2012	2017
South Dakota	31.36	25.53	25.56	12.82	18.77	18.58
North Dakota	19.23	16.27	14.57	18.24	22.41	23.63

Unit: Millions Acres.

Table 2 displays the percentage of land use conversion for South and North Dakota in both 2007-2012 and 2012-2017 periods. In South Dakota, nearly 20% of grassland in 2007 was converted to cropland by 2012, while 4.40% of cropland as of 2007 was converted to grassland.

[2] Note that various methods such as resampling are available to address the pixel size difference issue. Different choice of methods could result in slight discrepancies in calculated acreages.

Table 2: Percentages of land use conversion in the Dakotas during 07-12 and 12-17 periods

	2007-2012		2012-2017	
State	Grass to Crop	Crop to Grass	Grass to Crop	Crop to Grass
South Dakota	19.59%	4.40%	5.17%	5.73%
North Dakota	19.90%	3.32%	7.81%	2.75%

Figure 1 displays geographical locations of land use conversions in South Dakota, during the period 2007-2012. An apparent trend from Figure 1 is that the majority of grassland conversion to cropland during that time occurred in the middle portion of eastern South Dakota (SD), as indicated by the continuous light green colored area in that region. During this period, conversions from cropland to grassland also occurred. However, compared to the first type of conversion, the latter was less frequent and was scattered all across the state, with higher intensity east of the river.

Geographical locations of land use conversions in South Dakota from the five-year period 2012-2017 are provided in Figure 2. In contrast to Figure 1, Figure 2 shows that the middle of eastern SD, where most conversions occurred from grass to cropland during 2007-2012, saw substantial reversion to grass during 2012-2017. Table 2 also reveals that by 2017, 5.73% of cropland as of 2012 had converted to grassland. Meanwhile the grassland to cropland conversion rate reduced significantly in SD, from 19.59% to 5.17%.

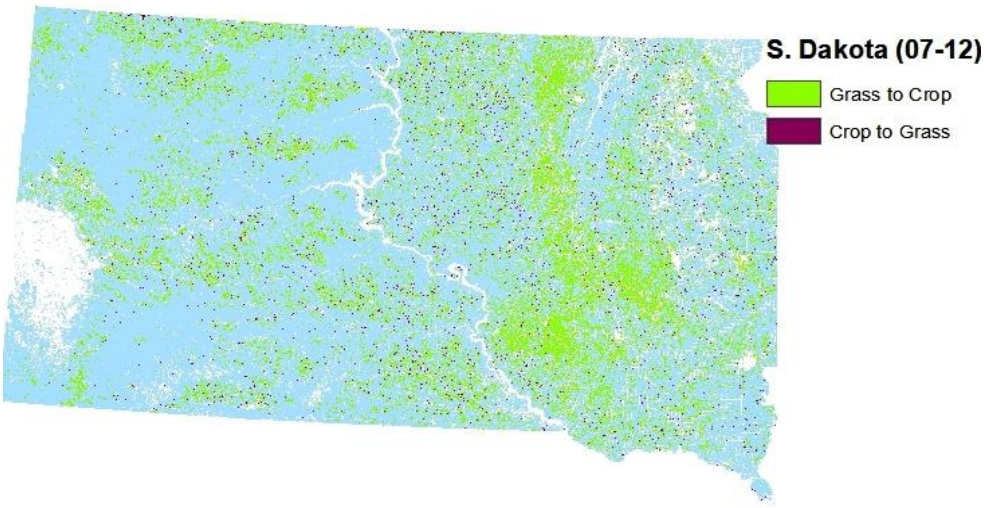

Figure 1: Land use conversions in South Dakota, between 2007 and 2012

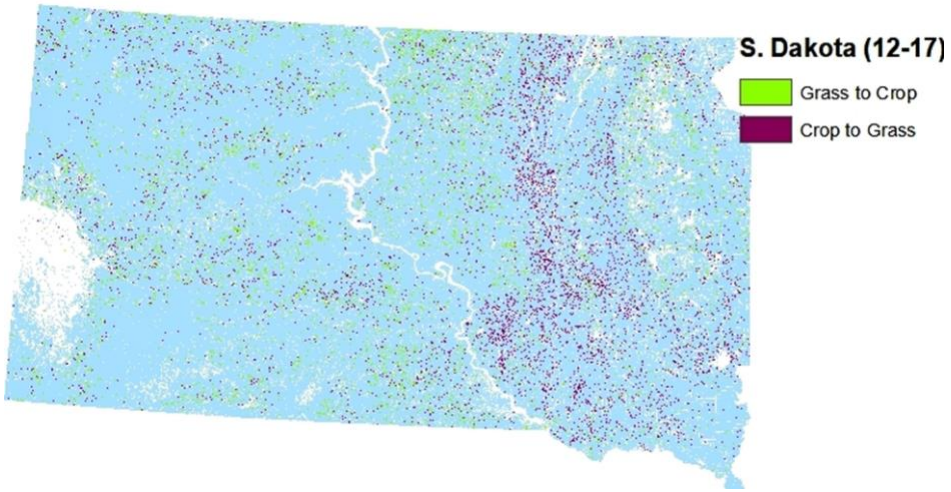

Figure 2: Land use conversions in South Dakota, between 2012 and 2017

Compared to SD, grassland to cropland conversion in North Dakota (ND) occurred more towards the west side of the state during 2007-2012 period (Figure 3). A major reason is that there was little grassland remaining to convert in eastern counties of ND, as shown by a cursory view of cropland data layer in North Dakota in 2007 (https://nassgeodata.gmu.edu/CropScape/). Even though grassland to cropland conversion rate has been curtailed during 2012-2017 period (Table 1), more grassland to cropland conversion activity occurred in ND when compared to SD in the latter period. In constrast, the rate of conversion from cropland to grassland has been consistently lower for ND when compared to SD, especially during the period of 2012-2017.

Nevertheless, land use change in ND displayed the same general trend as SD during the two periods (Table 1), in that there is a very high grassland to cropland conversion rate during 2007-2012 (19.90%), but the conversion rate has been greatly reduced during 2012-2017 period (7.81%).

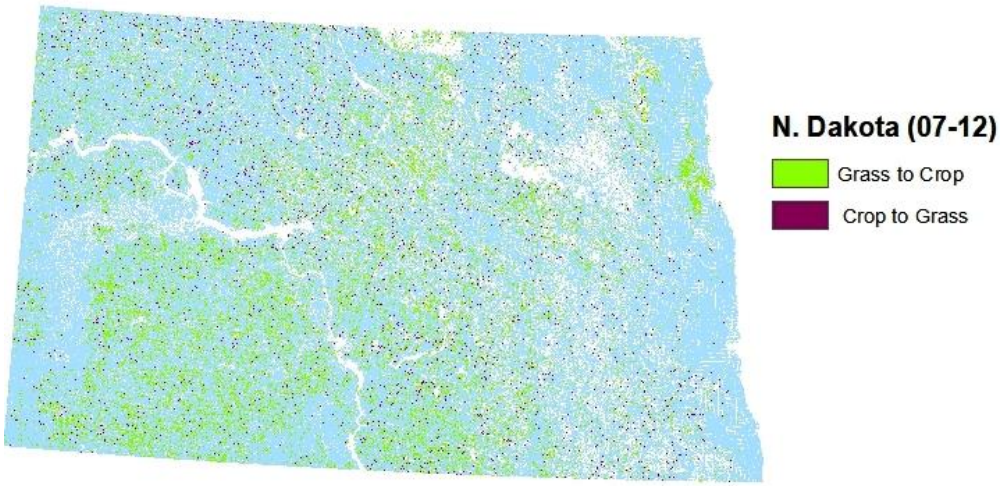

Figure 3: Land use conversions in North Dakota, between 2007 and 2012

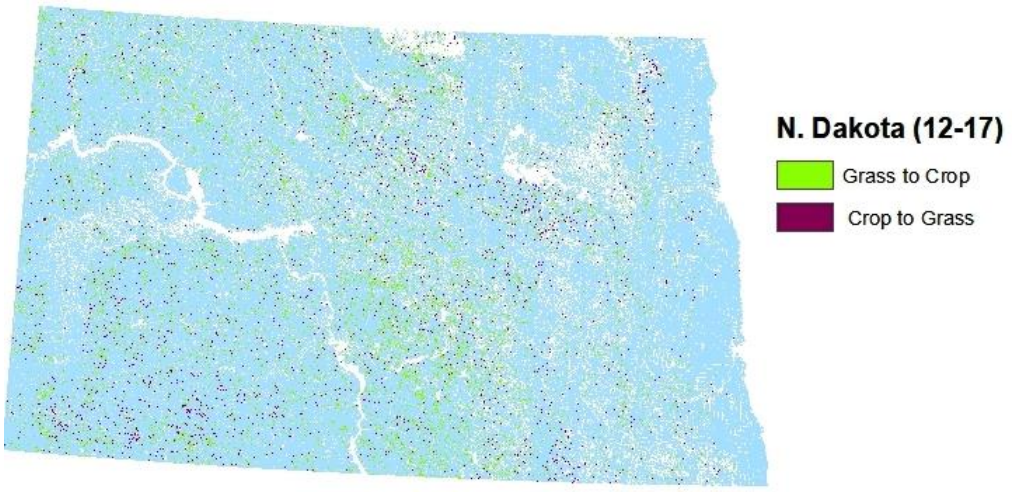

Figure 4: Land use conversions in North Dakota, between 2012 and 2017

To investigate the relationship between land conversion rates and crop prices, we charted in Figure 5 crop prices for the area's three major annual crops from 2000 to 2017, a period that covers our land use conversion periods. As indicated by Figure 5, there is an overall increasing trend in crop prices from 2005 to 2012, especially during 2009 to 2012. From 2012 and onward, however, crop prices have been generally declining. As of 2017, the prices received for the three major crops in South Dakota were at the about same level as those in 2009. The correpondence between crop prices and land conversion rates supports the hypothesis that land use conversion decisions are responding to crop price changes. This finding is also consistent with a 2015 farmer survey findings in eastern Dakotas (Wang et al., 2017), which showed that output prices were the greatest motivating factor in farmers' land use change decisions.

Note that even though crop prices in 2017 are about the same as those of 2009, grassland acres are not likely to rebound to the same level as of 2009 in the near future. In economics, this phenomena is referred to as hysteresis, which means that even after the initial cause (here referring to the rising crop price) for the effect (here referring to the declined grassland acres) are removed, such effect will still persist into the future. This is partly due to reasons such as transaction costs in land use changes, as costs associated with conversion cannot be recovered if farmers have made major physical and human capital investments in gearing up to manage more cropland acres.

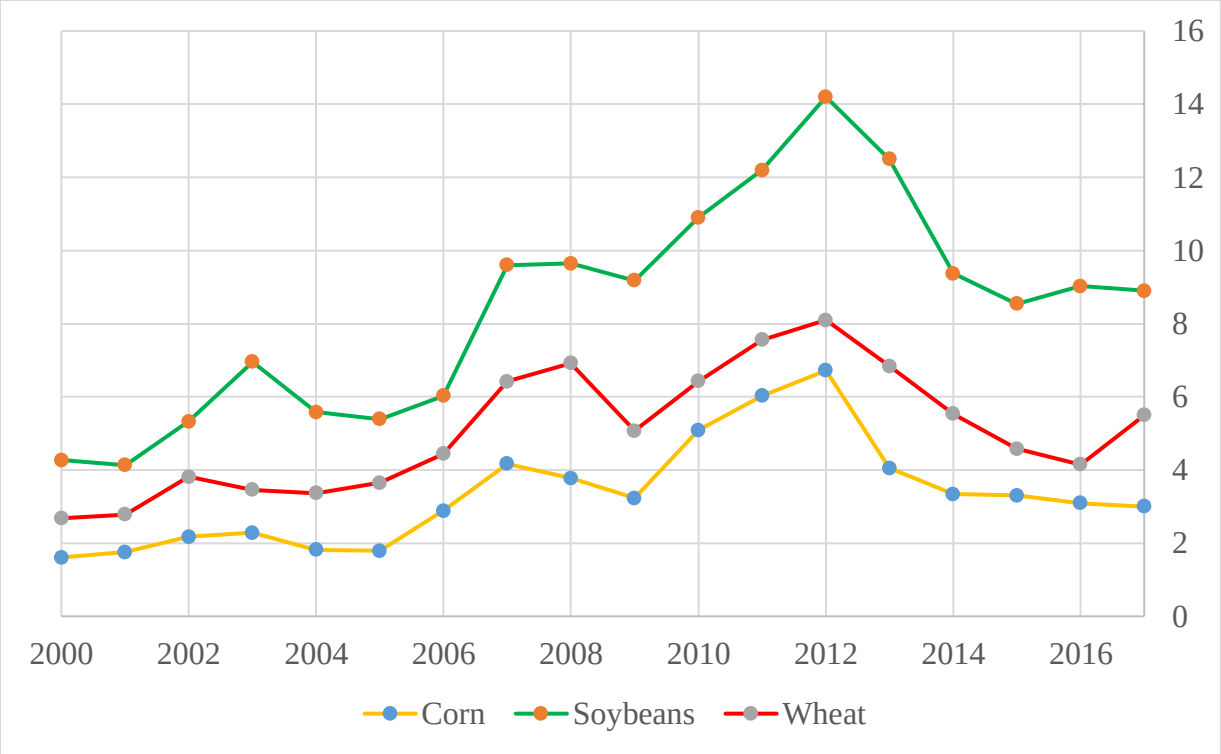

Figure 5: Prices recevied in South Dakota as measured in $/BU for corn, soybeans and wheat, 2000-2017 (Source: USDA NASS).

Conclusion

Quite a few studies (Wright and Wimberly 2013; Reitsma et al. 2014; Lark et al. 2015) have analyzed land use conversion rates in the Dakotas when commodity prices were on the rise. However, to our knowledge, no study has followed up on these studies to examine land use responses to the lower commodity prices during the 2012-2017 period. Using CDL data, the same data source used in the aforementioned publications, we analyzed land use changes between 2007 and 2012, and then between 2012 and 2017. Compared to the 2007-2012 period, a period that saw significant decline in grassland area in the Dakotas, we found that less grassland has been converted during 2012-2017. However, continual conversion from grassland to cropland (7.81%) in North Dakota suggests there may exist other key non-price factors driving land use changes at the local level.

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