Land Use and Climate Change in the Dakotas

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Introduction

CLIMATE CHANGE is a key determinant of outputs that can be obtained from land resources and how land-use managers respond to commodity prices, technology and agricultural policy. Our research is concerned with assessing the drivers of recent land-use changes where the northwest edge of the U.S. Corn Belt intersects with the Dakota's Prairie Pothole Region (DPPR). Recently witnessed conversions of native prairies to crop production imply biodiversity losses, habitat loss for waterfowl species and costly cropping of less productive lands (Johnston 2014). The objectives of this study are to (a) characterize spatial and temporal patterns in land use, (b) assess climate change phenomena for North and South Dakota, and (c) compare the two.

Relevant Literature

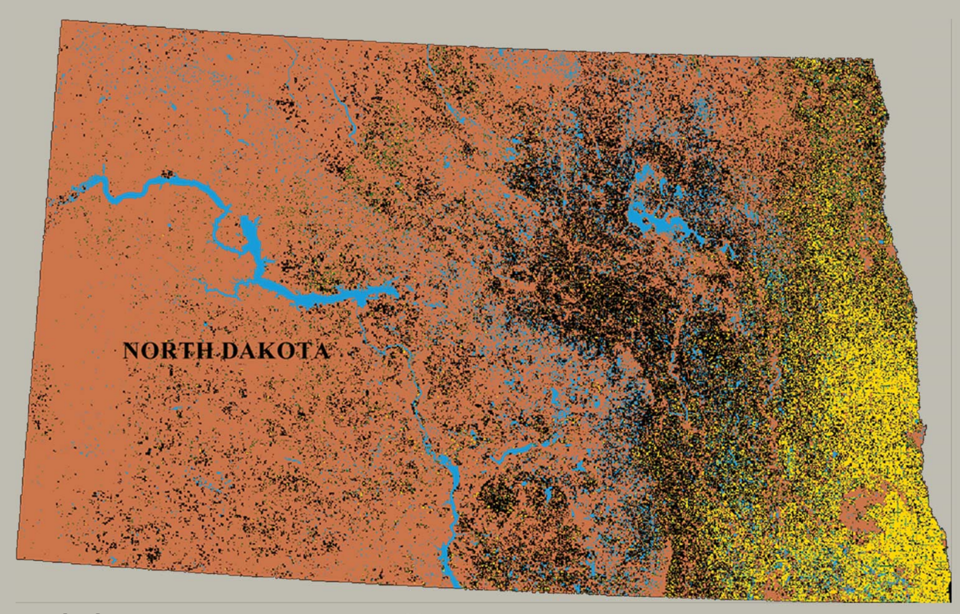
RECENT STUDIES that have characterized land use in the Dakotas reveal significant transitions from grass-based agriculture to corn/soy production from 2006 to 2011. Wright and Wimberley (2013) find a net 669,656 acres of grassland converted to corn/soy production in this period. Johnston (2014) finds that in 2006 corn/soy had a lower chance than grasslands of being re-grown in subsequent years, a trend that had reversed by 2011.

On climate change, Shafer et al. (2014) find that, from 1981 to 2010, average temperatures increased southwards in the Dakotas and annual precipitation remained low at 15–24 inches, but was higher westwards. Shafer et al. (2014) project higher temperatures and uncertain annual precipitation levels (increasing if GHG emissions are higher) from 2041 to 2070, making this region vulnerable to future droughts. Kucharik's (2006) analysis to explain early corn planting dates in modern times, relative to the early 1980s, finds evolving technologies as a primary reason, rather than speculated trends of springtime warming.

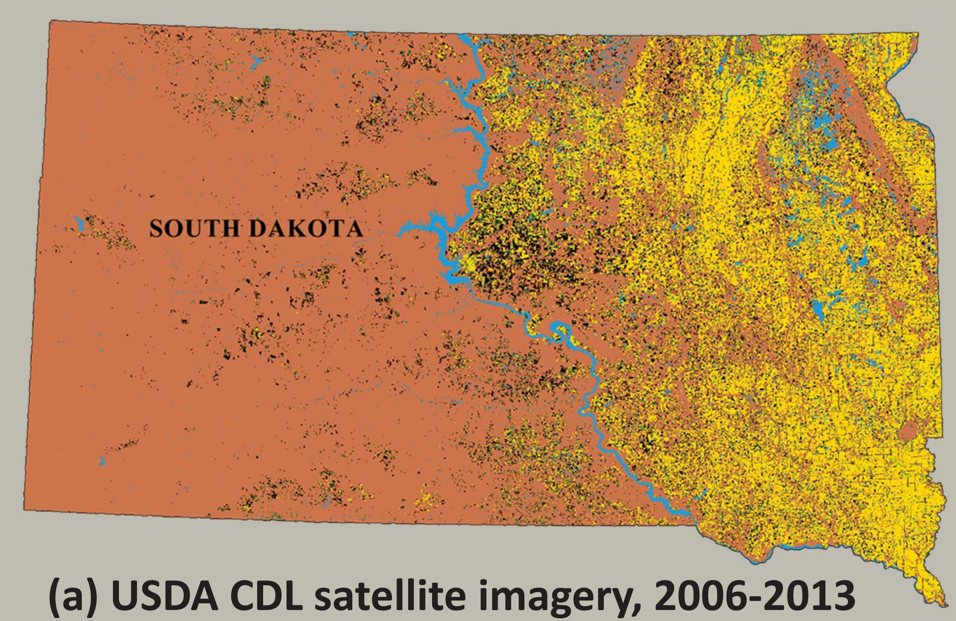
With weather patterns in the Dakotas driving agricultural lands to aridity and vulnerability to droughts, the aforementioned land-use transitions become an interesting phenomenon. However, research that explains these rapid transitions is lacking.

Data Analysis

Land Use



(a) USDA CDL satellite imagery, 1997-2013



(a) USDA CDL satellite imagery, 2006-2013

Corn/Soy to Corn/Soy · Other LUs to Corn/Soy · Corn/Soy to other LUs · Open water

Figure 1. Corn/soy transitions for North and South Dakota

Table 1. Pivot table showing land use transitions in the Dakotas between 1997 and 2010

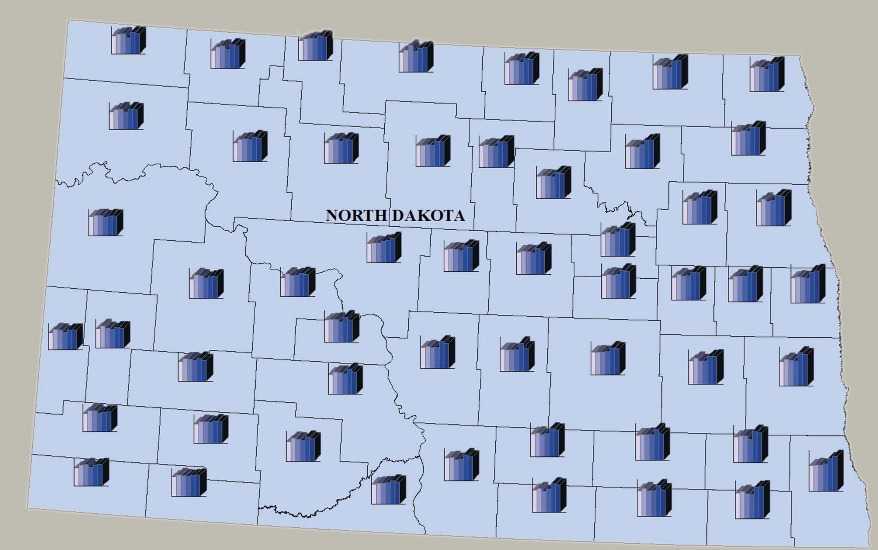
		2010 acres (millions)				Total
		Corn/Soy	Wheat	Grass*	CRP	(1997 acres)
1997 acres (millions)	Corn/Soy	6.59	0.92	0.62	0.23	8.35
	Wheat	4.08	5.34	0.88	0.47	10.77
	Grass*	1.57	0.87	37.73	0.17	40.34
	CRP	0.71	0.57	0.98	1.92	4.18
Total (2010 acres)		12.94	7.70	40.21	2.79	63.64

*Grass category includes three categories: Pasture, Hay and Rangelands.

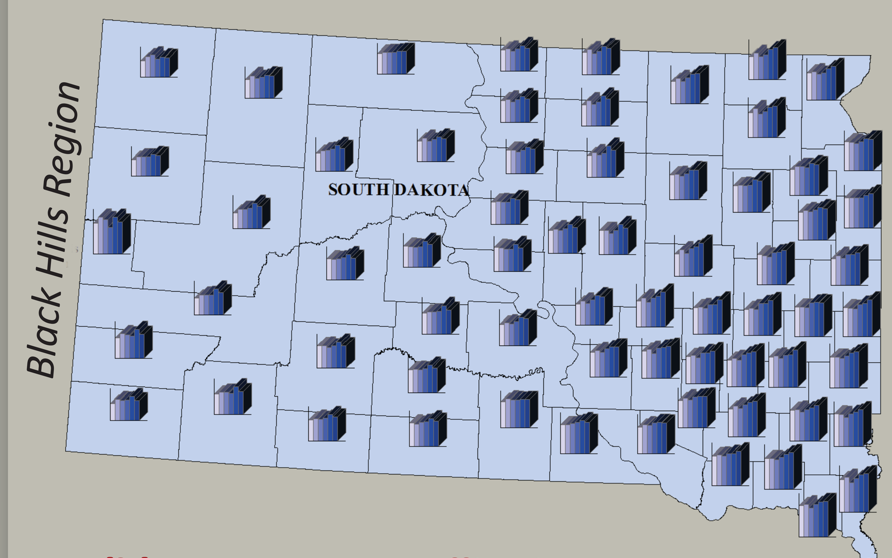
FIGURE 1 uses USDA Cropland Data Layer's (CDL) satellite imagery (1997–2013 for North Dakota and 2006–2013 for South Dakota) to provide visual depictions of spatio-temporal transitions between corn/soy and other land-use categories. It is evident from Figure 1 (a) that the edge of the U.S. Corn Belt, just east of the Missouri River, has shifted northwest over the period depicted. Since CDL data for South Dakota are unavailable before 2006, we supplement our analysis with National Resource Inventory (NRI) point-level data (1982–2010) to identify historical land-use changes for both states. Table 1 reinforces the findings of Figure 1 that corn/soy acreage increased by 55%. Decreasing acres of other agricultural and non-agricultural categories contributed to this growth. Table 1 also identifies loss of Conservation Reserve Program acres to agricultural uses.

Climate

COUNTY-LEVEL daily fluctuations in precipitation, growing degree-days (GDD) and seasonal length from 1950 to 2014 were obtained using the Applied Climate Information System query builder (maintained by NOAA Regional Climate Centers)**. Figure 2 depicts regional differences in precipitation trends and GDD trends. For example, in the last four decades, the Dakotas have experienced stronger positive trends in precipitation in the eastern region than in the western region.



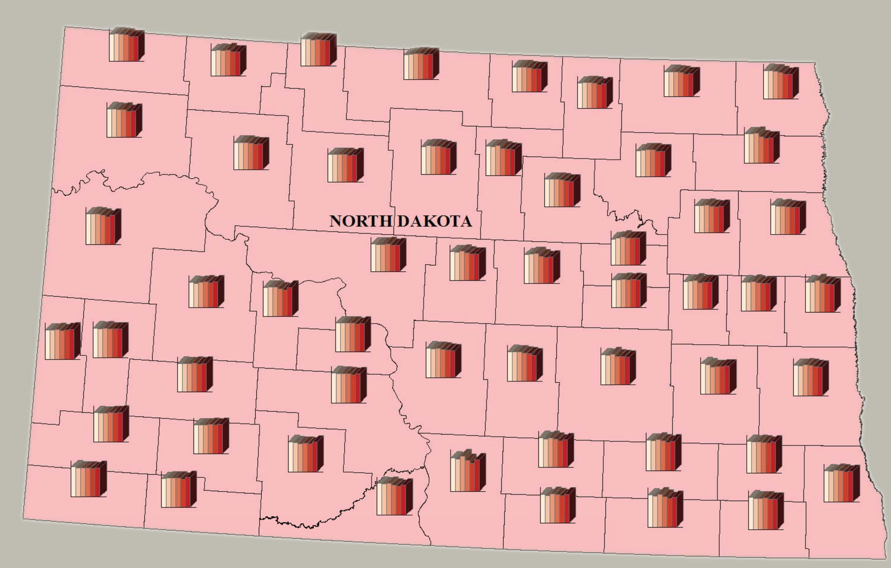
(a) USDA CDL satellite imagery, 2006-2013



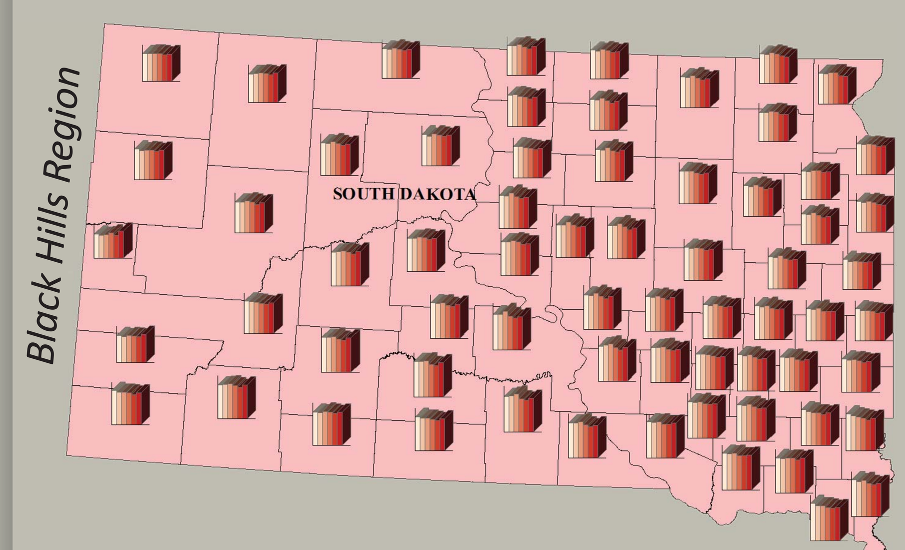
(b) USDA CDL satellite imagery, 2006-2013

1951-1960 · 1961-1970 · 1971-1980 · 1981-1990 · 1991-2000 · 2001-2010

Figure 2. Spatio-Temporal Trends for Decadal Precipitation in North and South Dakota, 1951-2010



(a) USDA CDL satellite imagery, 2006-2013



(b) USDA CDL satellite imagery, 2006-2013

1951-1960 · 1961-1970 · 1971-1980 · 1981-1990 · 1991-2000 · 2001-2010

Figure 3. Spatio-Temporal Trends for Decadal GDD in North and South Dakota, 1951-2010

Relevant Observations

INCREASED PRECIPITATION in the eastern Dakotas region seems to have influenced higher corn production, given that corn is a water- thirsty crop. Where GDD has declined slightly over the last few decades, extended seasonal length (not shown here) may be have promoted corn-based agricultural production. Other possible contributors to observed land-use change include federal agricultural and natural resource policies, changing market prices and technological innovation.

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Acknowledgements:

**We thank Benjamin Uecker and Dr. F. Adnan Akyuz at North Dakota State University for compiling the weather data and sharing it with us.
This research is part of a collaborative project supported by the USDA-National Institute of Food and Agriculture, award number 2014-67003-21772.