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Summary

Grasslands play a key role in providing wildlife habitat and recreation, as well as in range and pasture livestock production systems by producing high quality animal protein for human consumption. Croplands provide high quality grains for human consumption, coarse grains for ethanol production, and along with forages, feed for confined livestock production systems. These livestock systems also produce high quality animal protein for human consumption. Both land use systems play important roles in a wide range of societal issues facing South Dakota including economic productivity and development, water quality and quantity, health of rural communities, urban development, and additional aspects of quality-of-life long associated with the state. The purpose of this study was to estimate land use changes in South Dakota from 2006 to 2012. Estimates of land use changes were calculated based on proportions of visually observed land use using high resolution imagery (< 2-m resolution) at the same 14,400 sampling points in the years 2006 and 2012. Between 2006 and 2012, the estimated grassland losses were 1,837,100 acres (±21,100). Grassland losses resulted in increased acres devoted to cropland (1,439,500 acres ±15,600), roads + buildings (non-agricultural purposes, 27,400 acres ±110), wetlands + forest (habitat, 126,800 acres ±690), and open water (243,300 acres ±860). The consequences of changes in land use in South Dakota may impact a wide range of stakeholder and interest groups, as well as society in general.

Introduction

The grains produced by the nation's croplands have long provided food and the wealth required for the industrialization of the United States economy. Grasslands provide a wide range of ecological and recreational goods and services, as well as produce a large portion of the demand for livestock feed grains produced from croplands. The conversion of grassland to cropland must be considered objectively, with benefits balanced with possible detriments. First, as history has shown, not all land can be sustainability converted to crop production. Land conversion can reduce wildlife habitat and may increase soil erosion from water and wind. The loss of grasslands may also change the composition of agriculture in the state, as grasslands are required for cattle and sheep production. On the other hand, grassland conversion to cropland can create wealth, as exhibited by the emergence of the ethanol industry, and may also reduce food shortages and prices. In the future, the need to increase food production sustainably will be an ongoing challenge.

Worldwide, grassland conversion is being driven by many factors including high grain prices (Omega Research, 1997), increasing global food demand (Tilman et al., 2011), genetic improvements (Chang et al., 2014), and policy changes designed to produce economic development (Clay et al., 2014). Accurate estimates are needed to assess the long-term risk of grassland conversion to other uses. The purpose of this research was to quantify land use changes using an approach that minimizes estimation and maximizes the ability to reliably duplicate the findings.

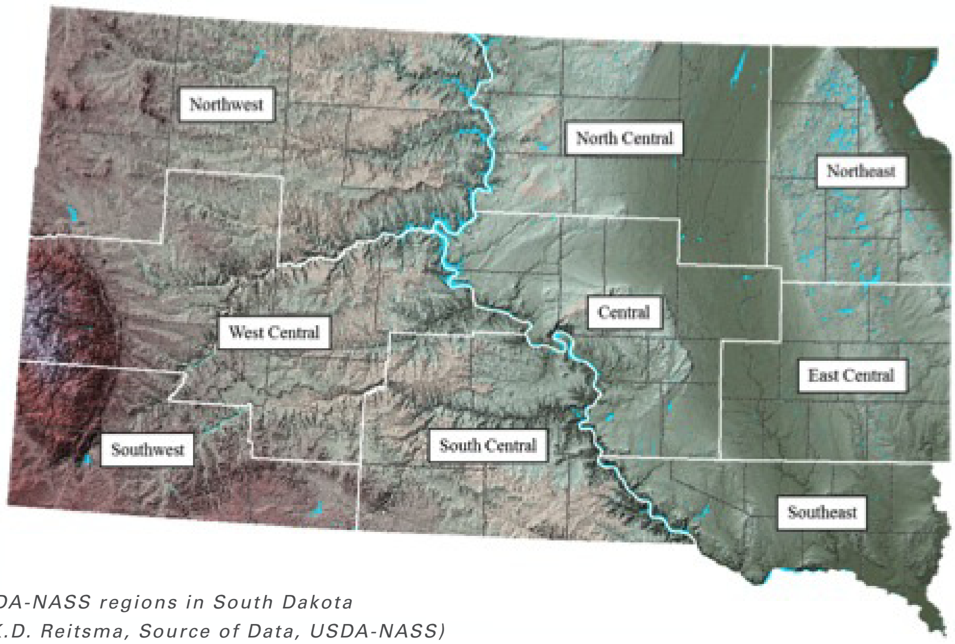

Figure 1. Nine USDA-NASS regions in South Dakota (Map Created by K.D. Reitsma, Source of Data, USDA-NASS)

Methodology

The study area was limited to the state of South Dakota, dividing the state into nine observation areas using the USDA-NASS reporting districts (Figure 1). Established statistical methods were used to calculate the number of observations needed to estimate land use with a 95% certainty (Freund & Walpole, 1980). In total, 1,600 observations were made at randomly selected points for each year (2006 and 2012) in each of the nine USDA-NASS reporting districts, resulting in a total of 28,800 observations statewide. The USDA-FSA Aerial Photographic Field Office aquires and distributes high resolution digital orthophotography through the NAIP (National Agricultural Imaging Program) (United States Department of Agriculture Farm Service Agency, 2013). These high resolution images were overlayed with selected observation points for 2006 (2-m resolution) and 2012 (1-m resolution), visually observed, and classified as cropland, grassland, non-ag, habitat, and water.

Cropland was defined as all cultivated crops other than hay and alfalfa. Grassland was defined as range, pasture, hay, alfalfa, and other grasslands. Non-ag was defined as roads, farmsteads, cities, and towns. Habitat was defined as wetlands and forest. Water was defined as open water. To determine total acres within a classification, point observations within a region were aggregated by classification and then multiplied by the region's total acres. Confidence intervals (95%) were calculated for each year and change between years using established statistical procedures (Freund & Walpole, 1980).

Results

Estimates from observations across South Dakota from 2006 to 2012 showed a net loss of 1,837,100 acres of grassland and a net gain of 1,439,500 acres of cropland (Table 1). The relative amount of grassland loss was not uniform across the state as the highest losses occurred in the Northeast district (-16.9%, ±0.6%) compared

Table 1. Changes in South Dakota croplands, grasslands, non-ag, habitat, and water from 2006 to 2012, based on 14,400 manually identified land uses each year, in acres.

	2006	2012	Change	95% CI
Cropland	15,546,600	16,986,100	1,439,500	15,600
Grassland	28,327,300	26,490,300	-1,837,100	21,100
Non-ag	1,590,300	1,617,700	27,400	110
Habitat	2,834,400	2,961,300	126,800	690
Water	1,055,600	1,299,000	243,300	860

Table 2. Land use changes in nine USDA-NASS regions in South Dakota from 2006 to 2012, 95% confidence interval shown in parenthesis.

	Cropland		Grassland		Non-ag		Habitat		Water	
NASS region	% Change	Acres *1000	% Change	Acres *1000	% Change	Acres *1000	% Change	Acres *1000	% Change	Acres *1000
Northeast	12.7(0.4)	239.7	-16.9(0.6)	-269.0	0	0	-8.1(0.1)	-24.0	17.2(0.3)	53.3
East Central	7.8(0.3)	163.0	-15.9(0.5)	-217.2	2.6(0.1)	4.9	18.5(0.3)	37.0	13.5(0.1)	12.3
Southeast	3.7(0.1)	82.8	-10.6(0.3)	-102.9	5.3(0.1)	8.9	0	0	14.7(0.2)	11.2
North Central	5.9(0.2)	164.9	-11.2(0.4)	-283.3	4.2(0.1)	7.2	37.8(0.4)	50.2	56.7(0.6)	61.0
Central	13.2(0.5)	266.3	-13.3(0.5)	-359.3	0	0	48.3(0.5)	44.9	55.6(0.6)	48.1
South Central	27.9(0.7)	209.3	-5.9(0.2)	-228.6	-2.4(0.1)	-3.2	7.4(0.1)	22.5	0	0
West Central	9.4(0.2)	63.9	-1.1(0.1)	-63.9	0	0	-0.5(0.1)	-4.9	10.0(0.1)	4.9
Northwest	12.1(0.2)	100.5	-1.4(0.1)	-118.2	0	0	-15.8(0.1)	-17.7	40.0(0.3)	35.5
Southwest	4.6(0.1)	7.9	-0.5(0.1)	-15.8	3.2(0.1)	2.6	0	0	28.6(0.1)	5.3

with Southwest district (-0.5%, ±0.1%) where the least loss was estimated (Table 2). Net increases of non-ag, habitat, and open water were also estimated from the same calculations. Based on the results from this study, it cannot be implied that there has been a change in wetland acres.

Changes in Land Use

In this study, loss of grasslands was associated with increases in croplands, non-ag uses, habitat, and open water areas. As shown in Table 3, these results support the trend reported by Wright and Wimberly (2013), but numerically are more similar to those reported by Decision Innovation Solutions (2013). Whereas methodologies differed, all three studies report substantial amounts of grassland conversion. A unique and important aspect of this study is the delineation of the state into the nine NASS regions (Figure 1). These regional results (Table 2) may help researchers and policy makers in the development of targeted and refined practices and policies to address regional concerns and improve the effectiveness and economic efficiency of possible interventions.

Increases in croplands are a concern because the conversion of grasslands may contribute to increased soil erosion and diminished water quality and quantity. However, if conservation tillage systems are adopted, the conversion of grasslands to croplands does not necessarily result in increased erosion. Using rainfall simulation, Lindstrom et al. (1994) reported that in east central South Dakota, the conversion of grass sod to a moldboard plow crop production system increased runoff from 0 to 66%. When the grass sod was converted to a no-tillage, dry-land crop production system, runoff was only marginally increased, from 0 to 3% of simulated rainfall. Across the state, erosion risks have been diminished by the wide scale adoption of reduced tillage systems (Clay et al., 2012), which in turn have resulted in decreased erosion losses. For example, in South Dakota there was a 34% decrease in wind, sheet, and rill erosion from 1982 to 2007 associated with conservation tillage adoption (United States Department of Agriculture Natural Resources Conservation Service, 2009).

Decreases in grassland acres is a concern because the loss of habitat may result in a decrease in wildlife populations. Declines in pheasant populations in 2013 (Runia, 2013) have been attributed to many factors including; an extensive drought in 2012, which resulted in wide scale harvesting of grass from ditches and CRP, reduced winter food supplies, adverse spring climatic conditions, which reduced reproductive success, as well as reduced habitat resulting from grassland to cropland conversion. Grasslands are a critical component of what is generally regarded as healthy pheasant habitat (Flake et al., 2012). Historically, the key pheasant region

Table 3. Estimated South Dakota grassland losses and time periods.

Study	Time period	Estimated grassland loss (acres)
This analysis	2006-2012	-1,837,100 (±21,100)
Decision Innovation Solutions (2013)	2007-2012	-2,172,019
Wright and Wimberly (2013)	2006-2011	-451,000

of the state of South Dakota has been the counties along the James River valley (Flake et al., 2012). This area is found in the North Central, Central, East Central, and Southeast NASS Regions where on a percentage basis, 11.2, 13.3, 15.9, and 10.6 of the grassland was converted to cropland respectively (Table 2). On an acre basis, these reductions represent approximately 58% of the total acres of grassland converted in the state reported in this study. Whereas a direct correlation between pheasant numbers and decreased grasslands is not possible from this study, these results would be supportive of that hypothesis.

In conclusion, additional research and demonstrations are needed to better define sustainable, integrated land management systems. These systems will need to provide adequate levels of grain and livestock production to profitably meet market demands as well as provide critical habitat for wildlife and minimize environmental impact on soil and water resources.

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