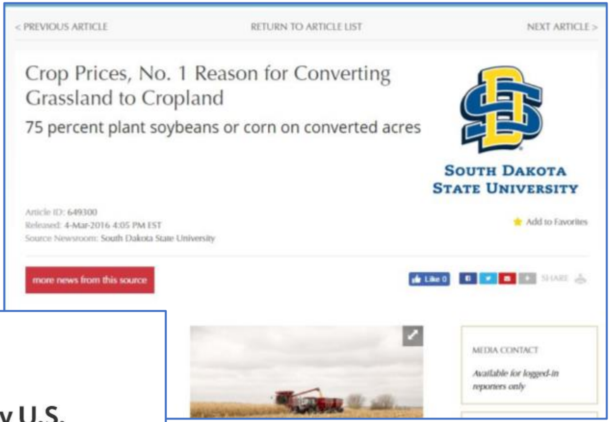
Impacts of Land Use and Land Cover Change on Water Quality in the Big Sioux River Basin: 2006-2016

Dinesh Shrestha, Department of Geography, SDSU
Advisor: Dr. Darrell Napton

Background

Diving forces…

- ➢ Biofuel demands
- ➢ High corn and soybean prices
- ➢ Grain (corn) demand
- ➢ Government payments
  - ➢ Crop insurance subsidies
  - ➢ Disaster payments


< PREVIOUS ARTICLE RETURN TO ARTICLE LIST NEXT ARTICLE >

Crop Prices, No. 1 Reason for Converting Grassland to Cropland

75 percent plant soybeans or corn on converted acres

South Dakota State University

Article ID: 649300
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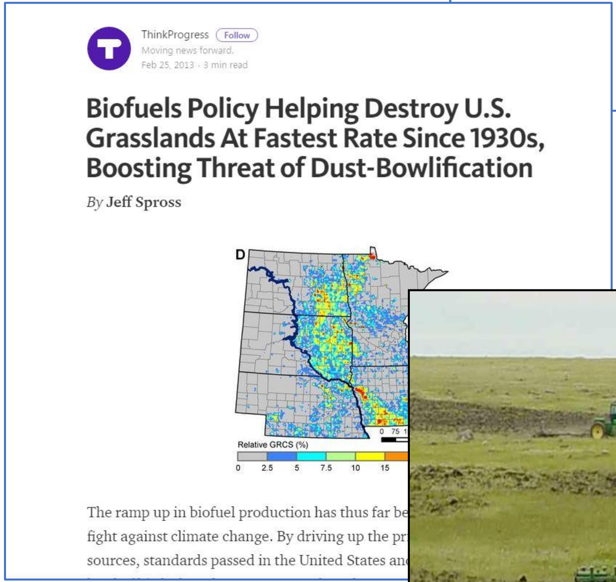
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Biofuels Policy Helping Destroy U.S. Grasslands At Fastest Rate Since 1930s, Boosting Threat of Dust-Bowlification

By Jeff Spross

The ramp up in biofuel production has thus far be
fight against climate change. By driving up the pr
sources, standards passed in the United States an

Sediments

BREAKING Fe…

South D… among dirtiest rivers in …

Pasture/rangeland, wastewater treatment or industrial plant

The Associated Press May 7, 2012 2

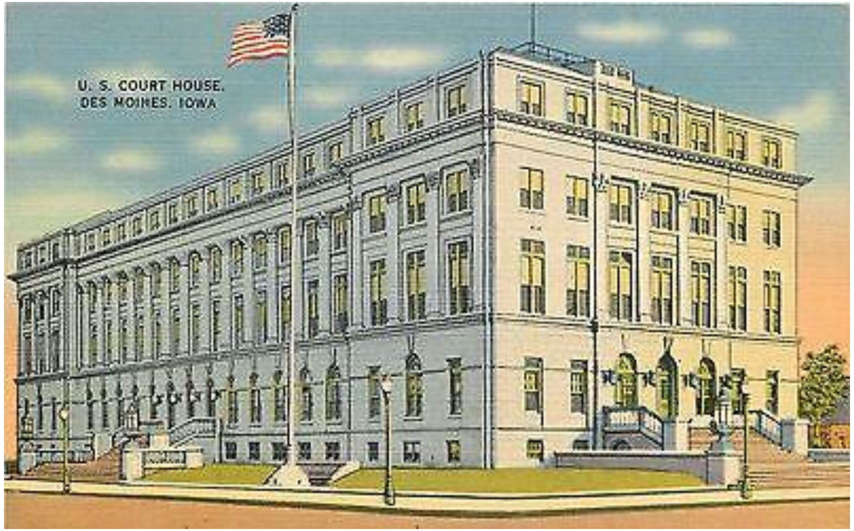
Nitrate

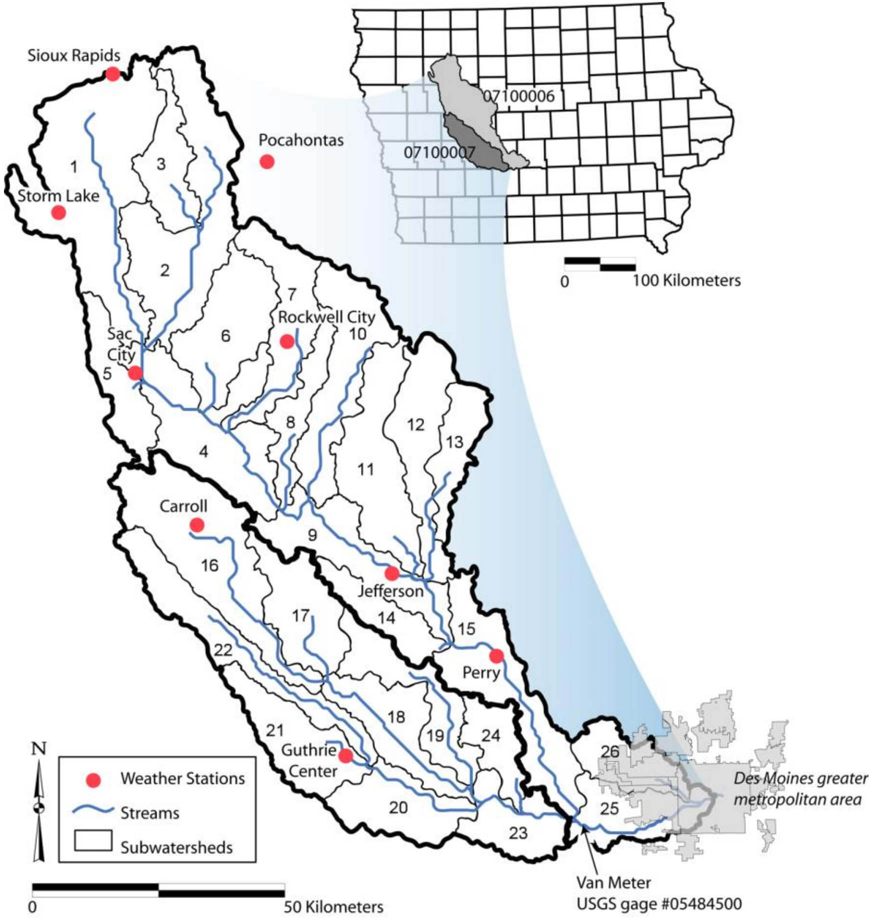
SIOUX FALLS -— The Big Sioux River snakes 42… miles down eastern South Dakota.

Latest

Man charged in Ra…
pleads guilty

Example





Raccoon River Watershed (Jha et al, 2007)

Topic: Impacts of Land Use and Land Cover Change on Water Quality in the Big Sioux River Basin: 2006-2016

Outline

Introduction

Background

Literature Review

Research Question and Objectives

Methodology

Expected Results

Summary, Conclusion, and Contribution

The objectives of the research are to determine:

(1) Land Use and Land Cover (LULC) change in the Big Sioux River (BSR) watershed,

(2) spatial and temporal trends of nitrogen levels in the BSR, and

(3) determine whether there is a correlation between LULC change and changes in nitrogen levels in the river.

Additional questions:

- How do we detect temporal trend in water quality?
- How can I use Mann-Kendall test to show the relation between LULC change and changes in nitrates level?

Grassland to cropland conversion in South Dakota

- Conversion of 1.8 million acres of grassland to cropland, in South Dakota, between 2006 to 2012.
- Most of the conversion took place in the eastern and central SD.

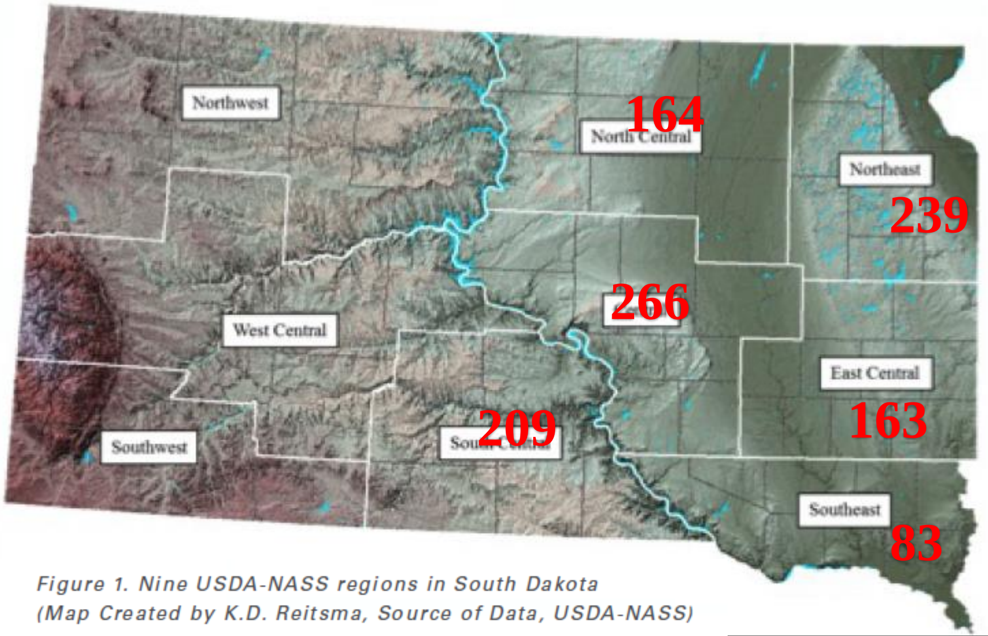
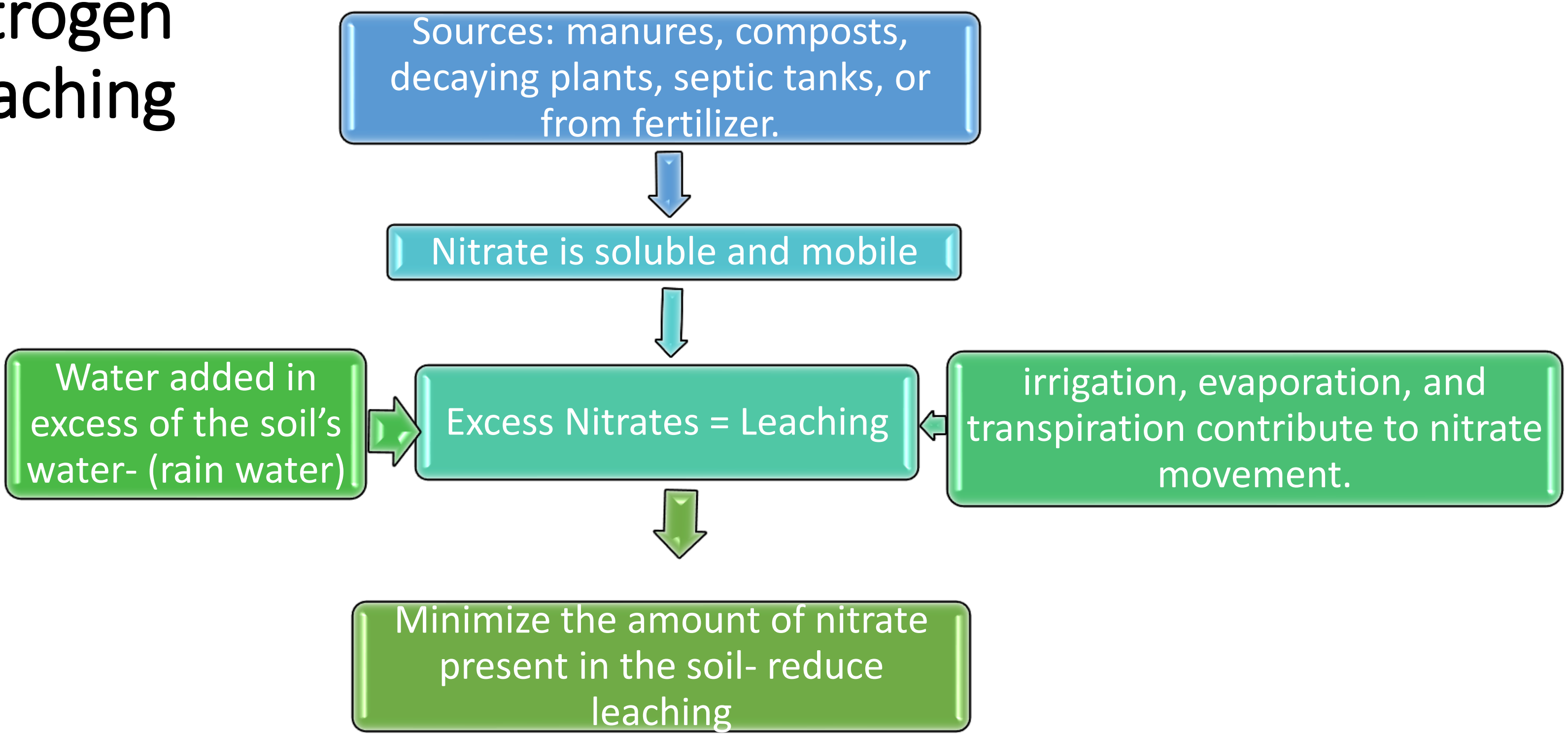


Figure 1. Nine USDA-NASS regions in South Dakota (Map Created by K.D. Reitsma, Source of Data, USDA-NASS)

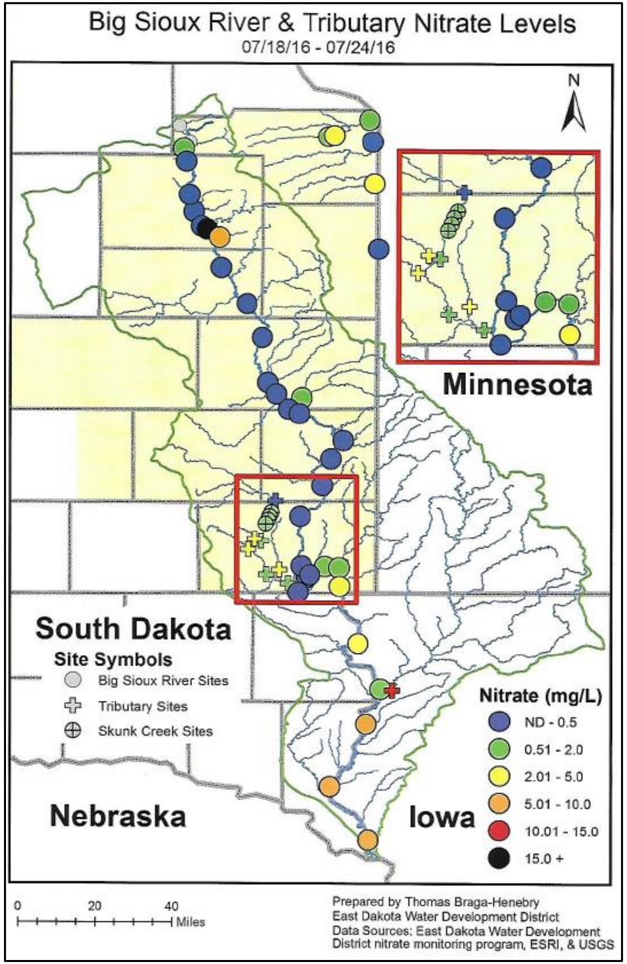
Nitrogen Leaching



Nitrogen Level in the BSR

- East Dakota Water Development District (EDWDD) reports increasing trend of nitrogen level in the BSR.

- Elevated nitrogen levels in river water are associated with anthropogenic sources such as synthetic fertilizers, manure, septic waste, and livestock wastewater

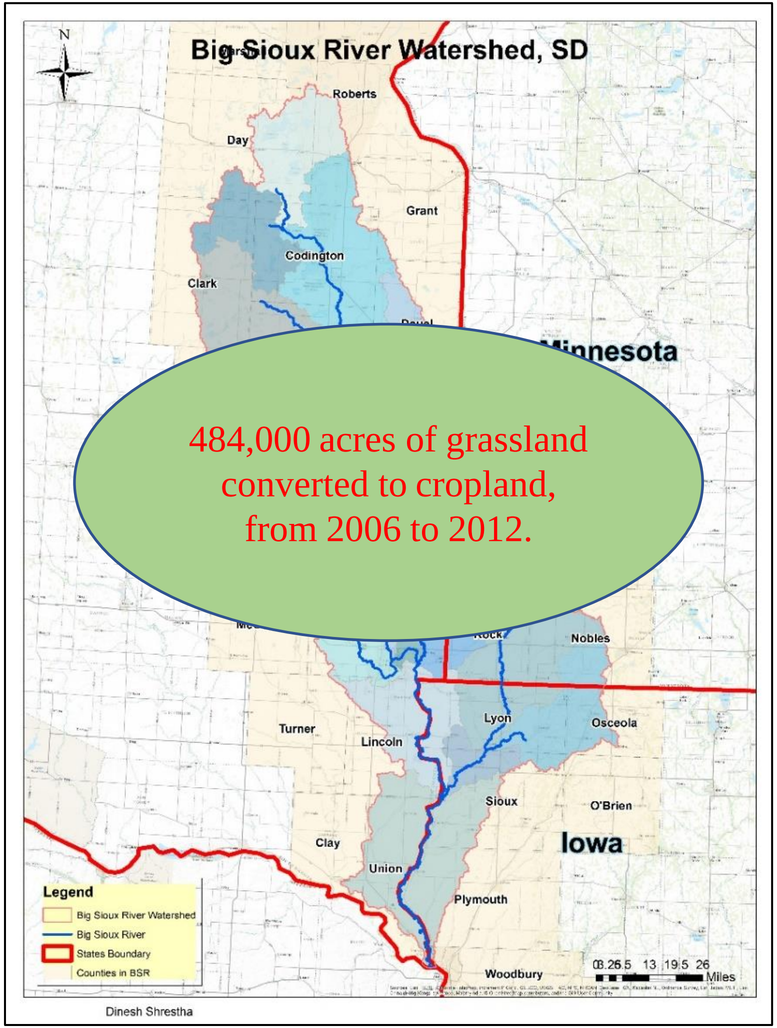


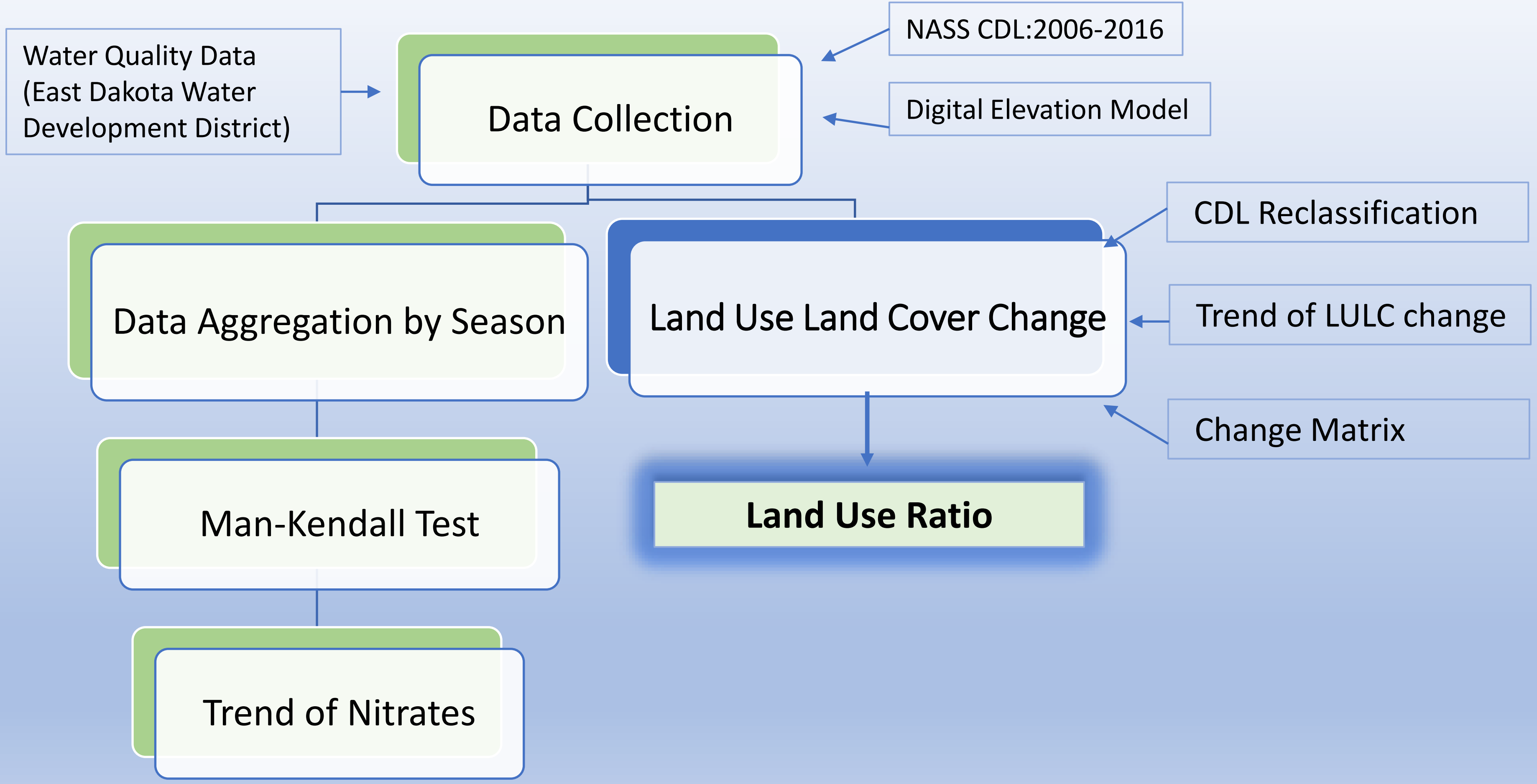
Methodology

- **Study Area:**

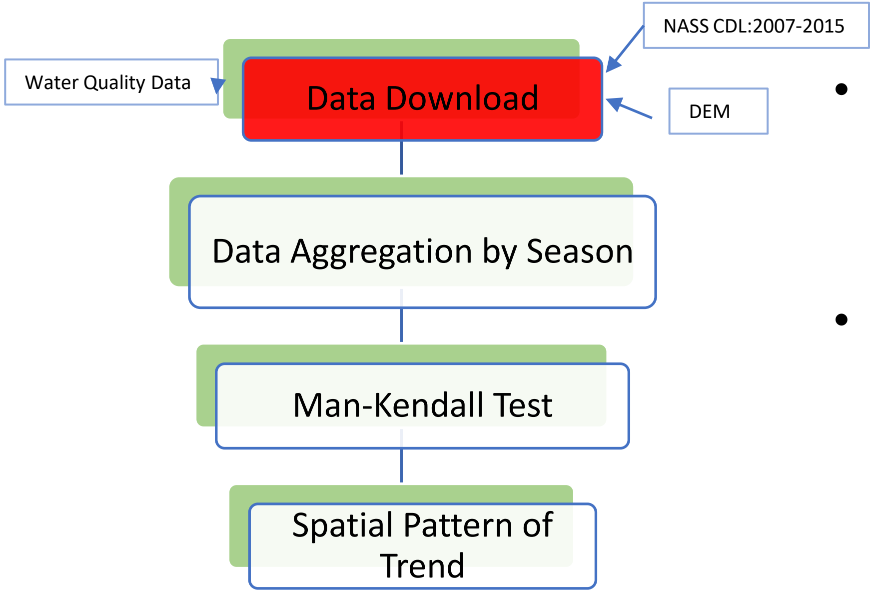
The Big Sioux River Watershed

  - Location: Lies mostly (6,000 sq. miles) in Eastern SD, (1,500 sq. miles) in Minnesota, and (1,500 sq. miles) in Iowa
  - 420 miles long river that begins in Roberts County, SD and flows south to Missouri River in Sioux City, Iowa




Water Quality Data (East Dakota Water Development District)
Data Collection
NASS CDL:2006-2016
Digital Elevation Model
CDL Reclassification
Data Aggregation by Season
Land Use Land Cover Change
Trend of LULC change
Change Matrix
Man-Kendall Test
Land Use Ratio
Trend of Nitrates

Methodology

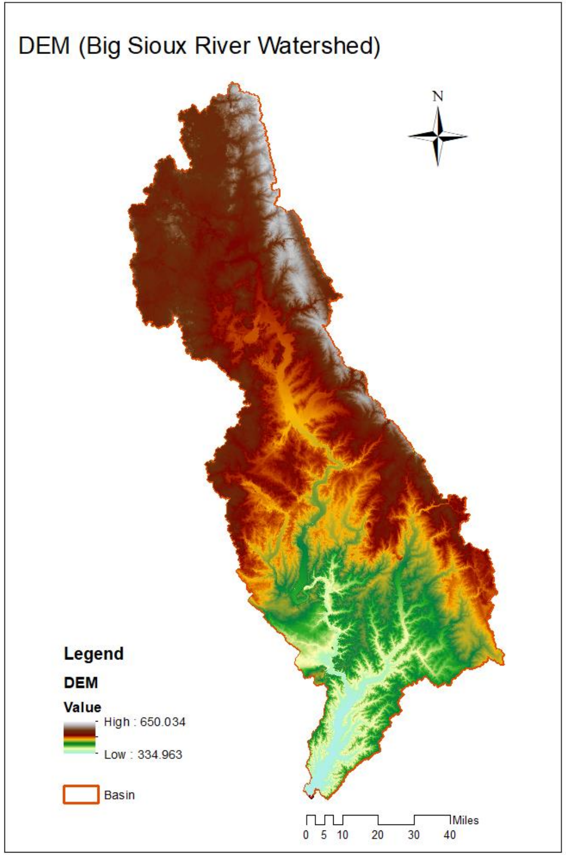


Data Download

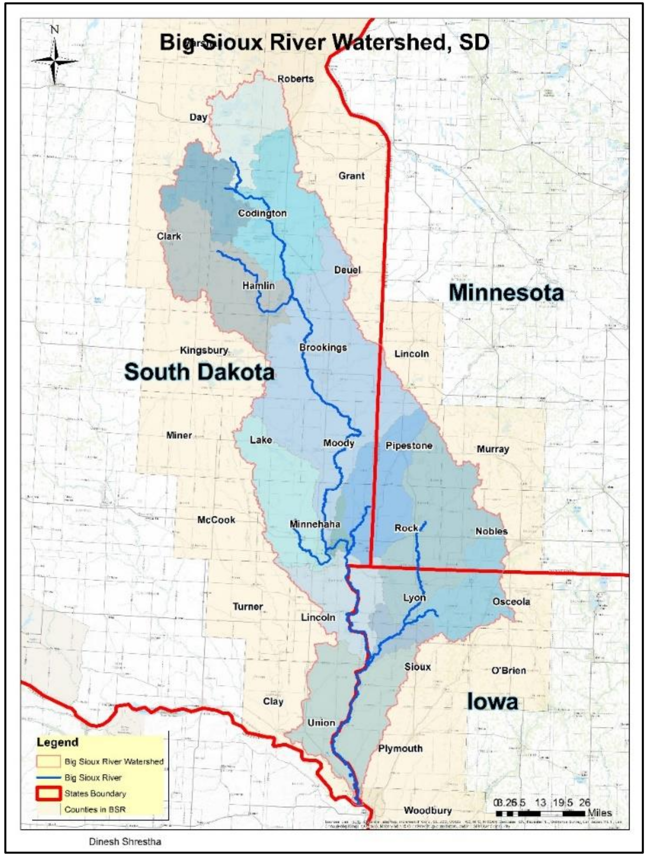
- Land Use Data
  - National Agricultural Statistics Service (NASS) CropScape-Cropland Data Layer (CDL): 2006-2016 [www.nass.usda.gov]
- Water quality data
  - East Dakota Water Development District, SD
  - US EPA- Surf your Watershed
- Others
  - Arc Grid representing a Digital Elevation Model for the Big Sioux River
  - Climate data [NCEI Map Viewer gis.ncdc.noaa.gov/map/viewer]
  - Streamflow (discharge) data [US EPA- Surf your Watershed]

Data

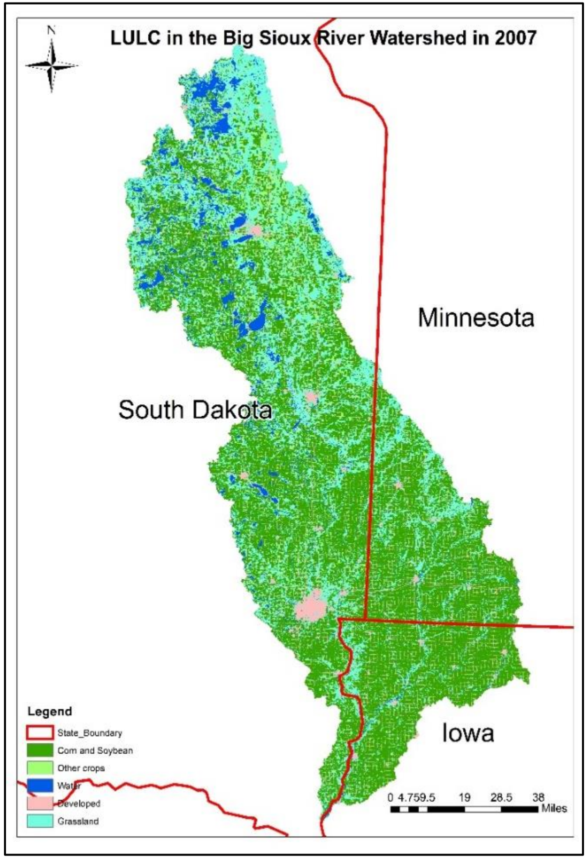
Digital Elevation Model (DEM)



Watershed and Sub-Watersheds



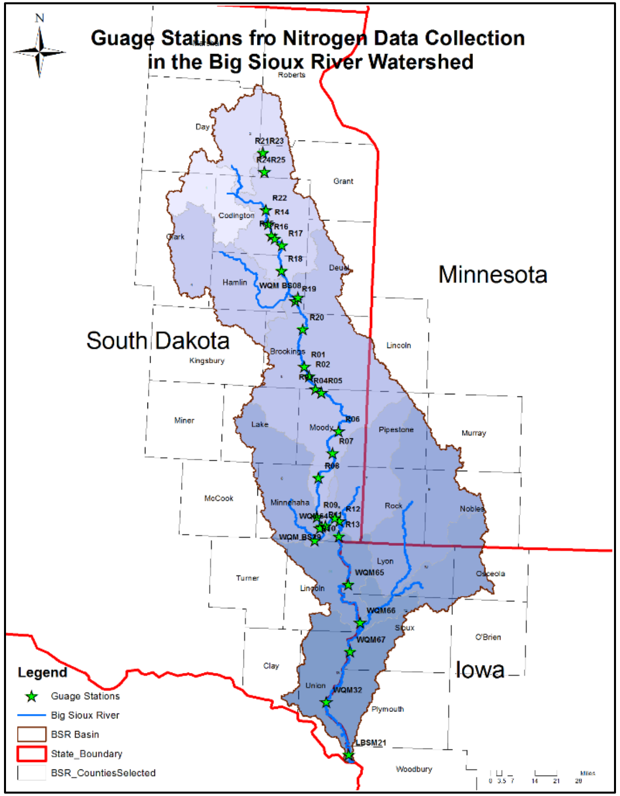
Cropland Data Layer 2007

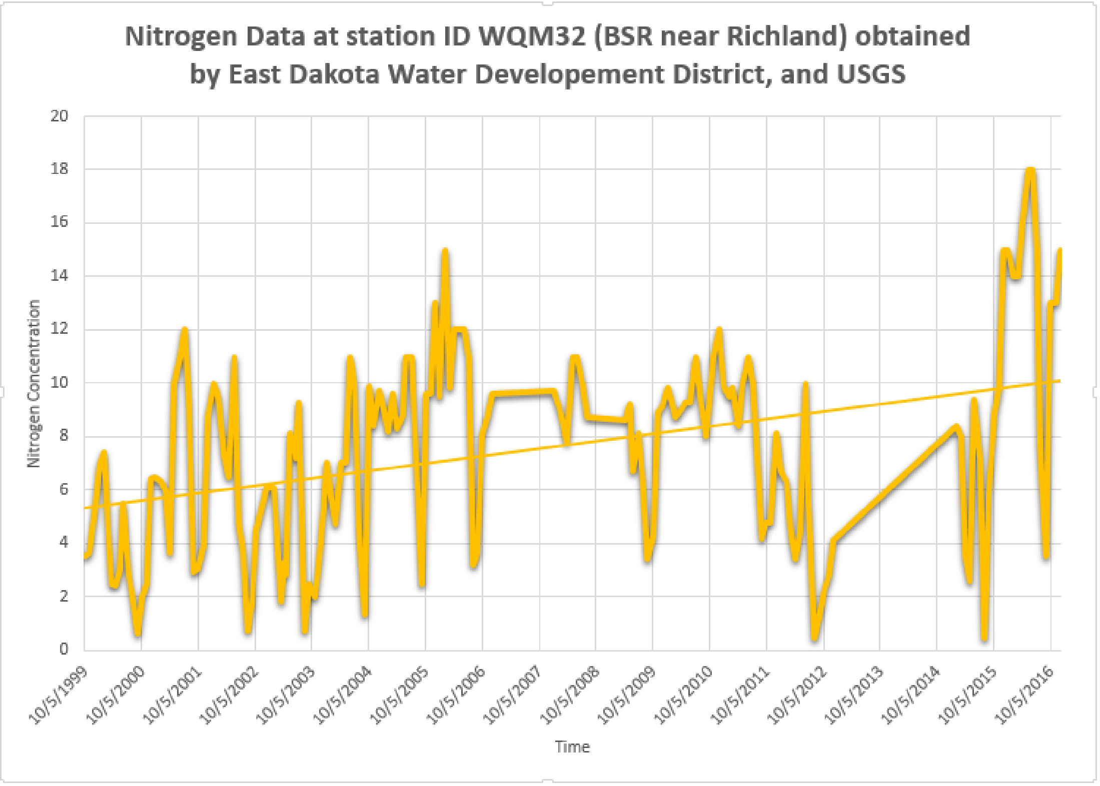


Data

Gauge Stations at BSR

Nitrogen Data





Data quality

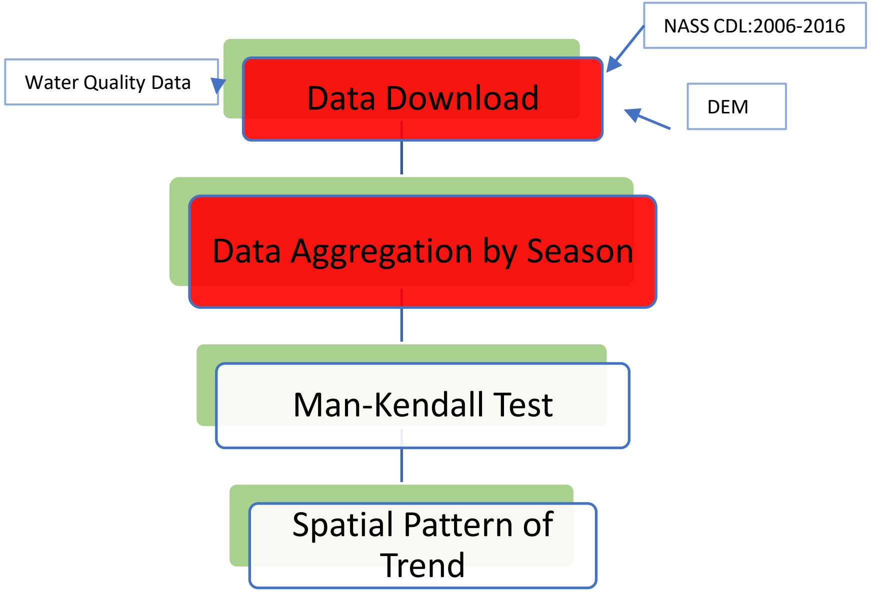
CDL Data

- CDL is designed and produced with the intent of monitoring annual land cover, and is widely used for cropland analysis.
- Non-crop areas are also identified but with less specificity and concern over accuracy
- 2006-08: 56m resolution, whereas 2009-15: 30m resolution [resample to smaller scale]

Nitrogen Data

- The collected data meet the National Water Program Guidance release by EPA.

Methodology

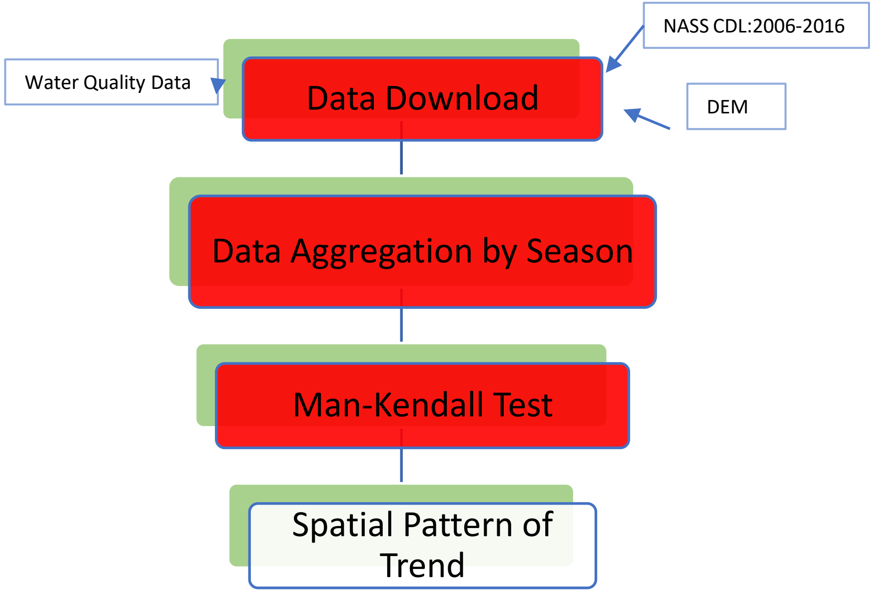


Data Aggregation by Season

- Availability of data
- Robust
- Missing values

Seasons	Months
Winter	Dec, Jan, Feb
Spring	March, April, May
Summer	June, July, August
Fall	Sep, Oct, Nov

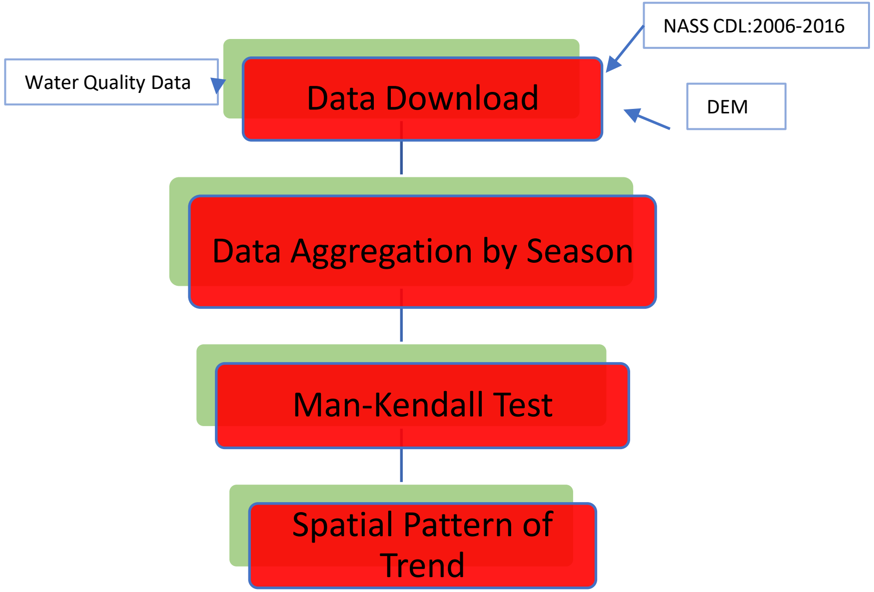
Methodology



Man-Kendall Test

- Non parametric trend analysis.
- Derives tau and level of significance
- Helps understand +ve, -ve or not significant trend
- Monotonic
- Estimates the number of stations with increasing and decreasing NO3-N trends
- Permits missing data to evaluate the tendency of change in nitrates

Methodology



Trend Analysis

- Categorize the 13 sub-watersheds into 3 sub-basins: Upper, Central, and Lower sub-basins.
- Increasing, not significant, and decreasing trend) for each sub-basins.
- Determine the stations showing significant **upward** and **downward** trends in nitrate concentrations in the Mann–Kendall.

Spatial changes of land use from 2006 to 2016

CDL Analysis

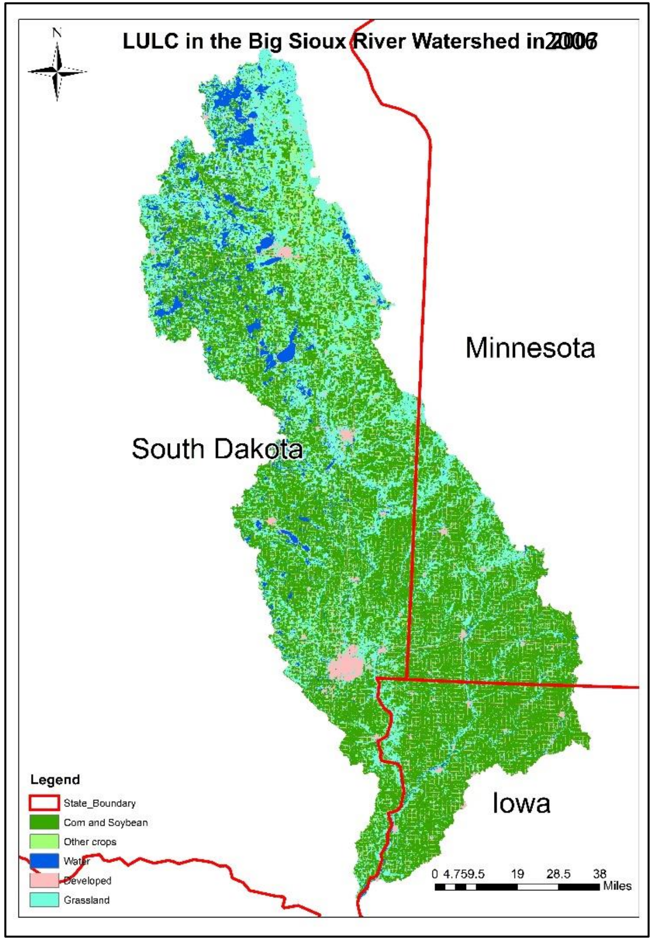
- Reclassification
- Trend of LULC change
- Change Matrix (Contingency Table)

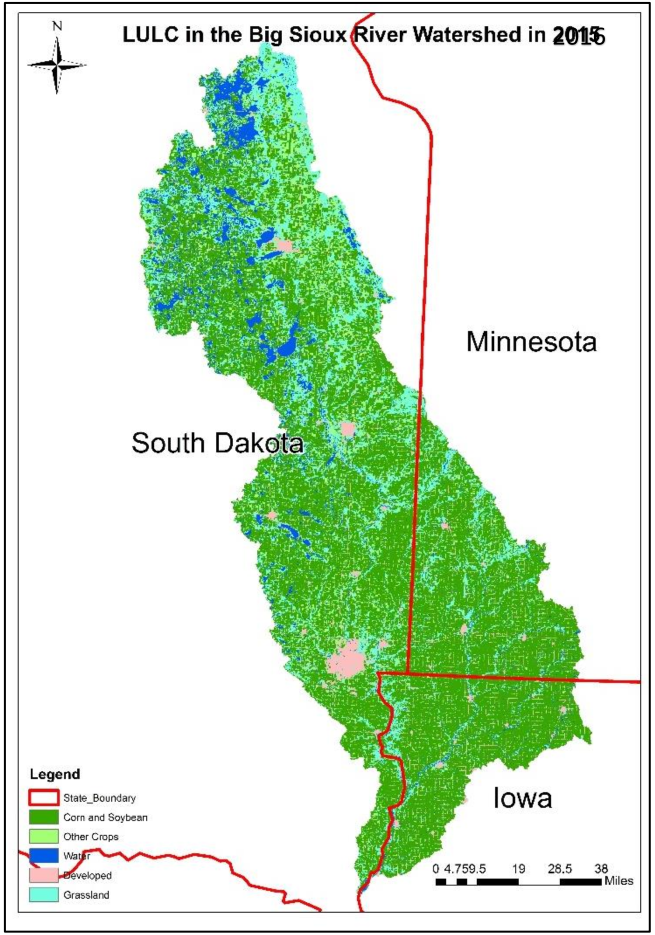
Reclassification Table

Classes	Categories
Corn/Soy	Corn and Soybeans
Other Crops	Wheat, Alfalfa, Sorghum, Oats, Millet, Pumpkin, Flaxseed, Potatoes, and other crops.
Water	Water, Wetlands
Developed	Open space, low/medium/high density
Grassland	Switchgrass, Grass/Pasture, Fruit Trees, Shrub land, Barren, and others

Corn/Soybean increased by **1.09 million** acres

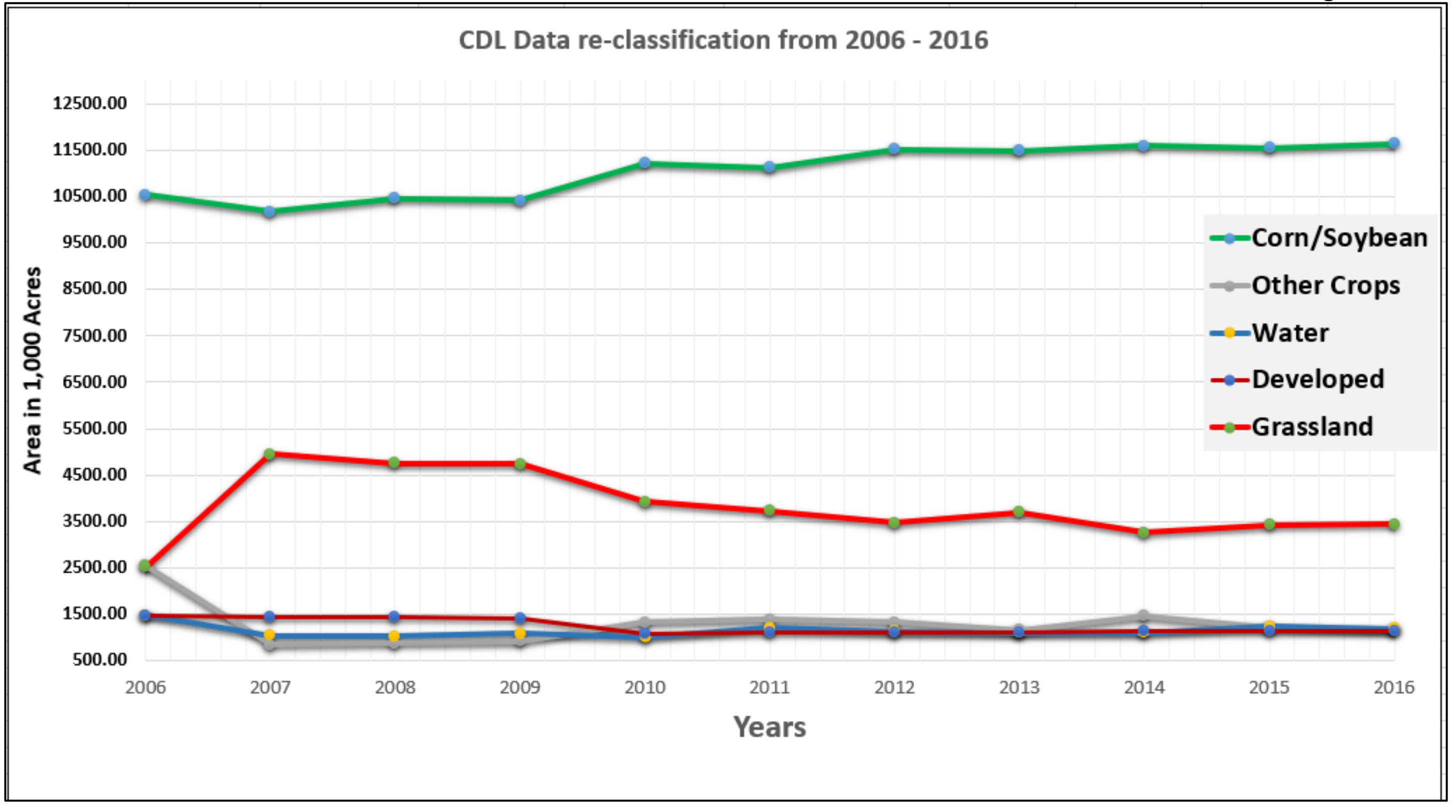
Grassland decreased by **917,000** acres





Land Use Land Cover Change

- Reclassification
- Trend of LULC change
- Change Matrix



Land Use Land Cover Change

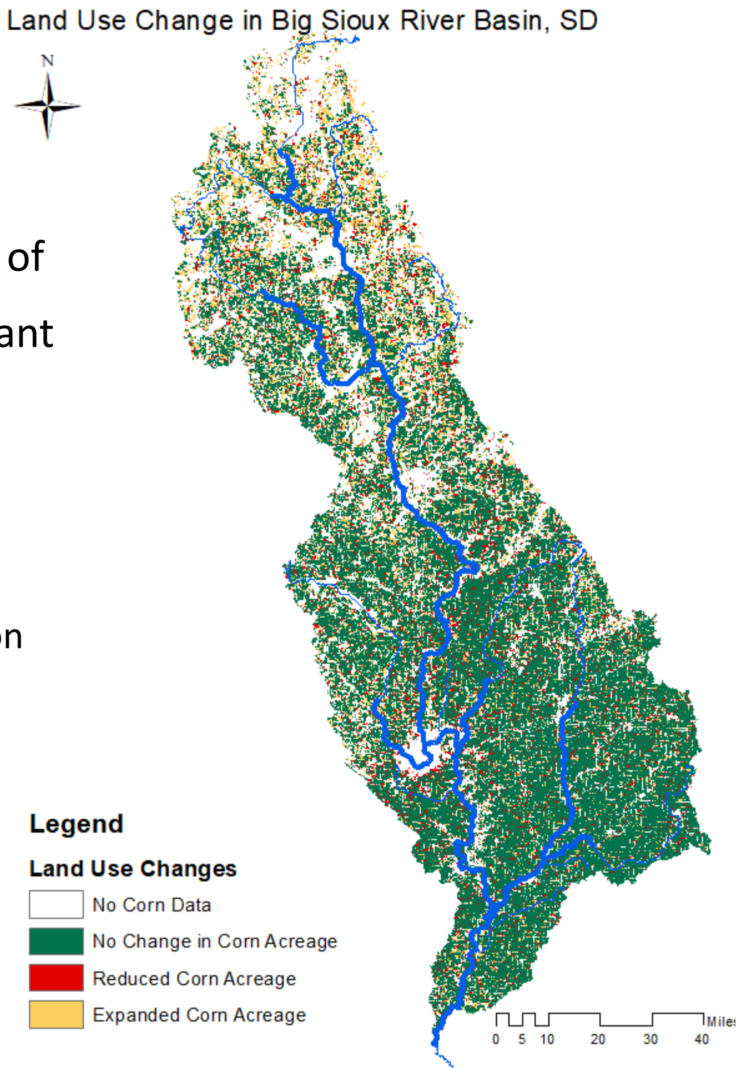
- Reclassification
- Trend of LULC change
- Change Matrix

Table: CDL Data Reclassification into 5 major class types, area in 1,000 of acres, from 2006 to 2016.

		2016	2016	2016	2016	2016	
		Corn/ Soybean	**Other Crops**	**Water**	**Developed**	**Grassland**	**Total**
2006	**Corn/Soybean**	**50.41**	**2.77**	**0.44**	**1.02**	2.17	**56.80**
2006	**Other Crops**	**6.26**	**1.75**	**0.64**	**0.29**	**[illegible].80**	**13.74**
2006	**Water**	**1.41**	**0.56**	**4.52**	**0.14**	**1.36**	**7.99**
2006	**Developed**	**1.92**	**0.26**	**0.20**	**4.22**	**1.29**	**7.88**
2006	**Grassland**	2.75	**0.93**	**0.57**	**0.41**	**8.91**	**13.58**
	Total	**62.76**	**6.26**	**6.37**	**6.07**	**18.54**	**100.00**

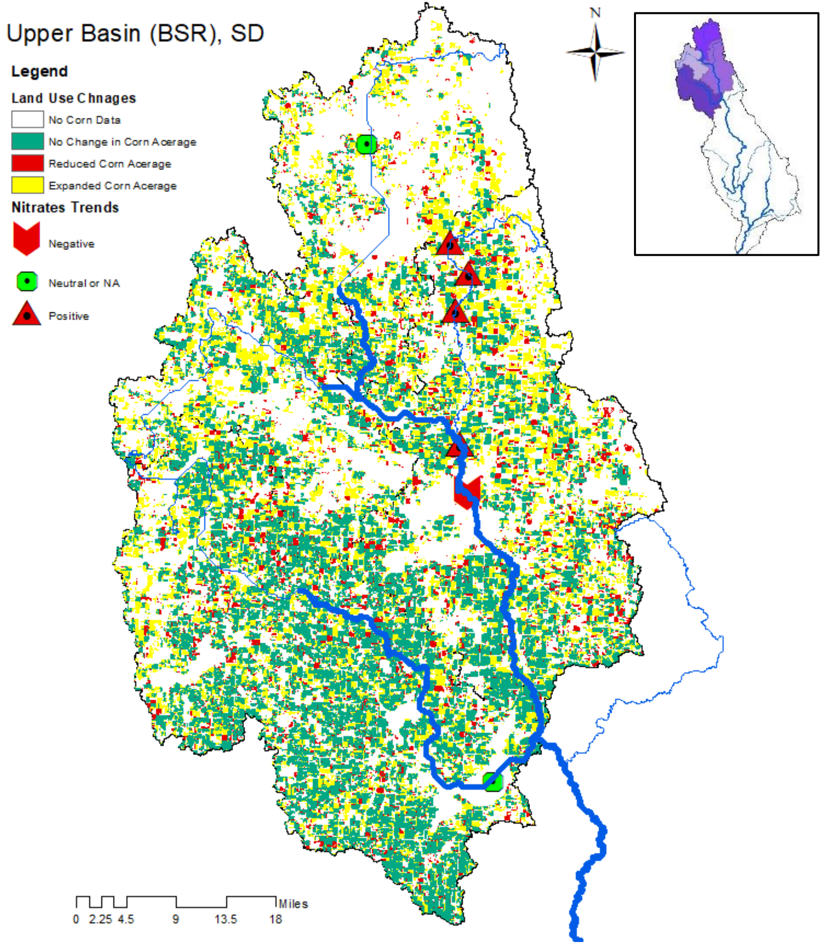
Land Change Ratio

- The change ratio of each land use category = area of each land use category in 2016 / the area of relevant land use in 2006.
  - If the calculated ratio > 1.0, the land use was considered to have expanded since 2006.
  - If the ratio < 1.0, the land use was reduced in relation to conversion to a different land use category.



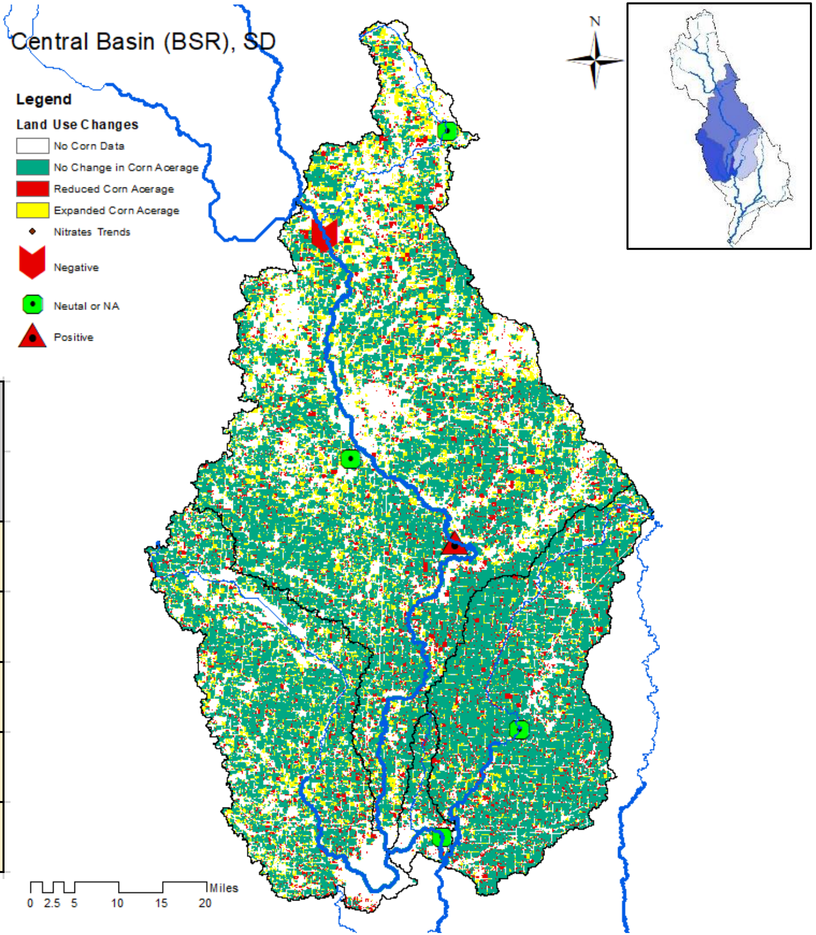
Land Change Ratio

Land uses Parameter for Upper Basin	2006	2016	Change Ratio
	Acres in 1000		
Corn/Soy	1831.26	2571.88	1.40
Other Crops	1506.32	558.79	0.37
Water	944.98	810.57	0.86
Developed	340.75	242.92	0.71
Grassland	896.07	1332.12	1.49



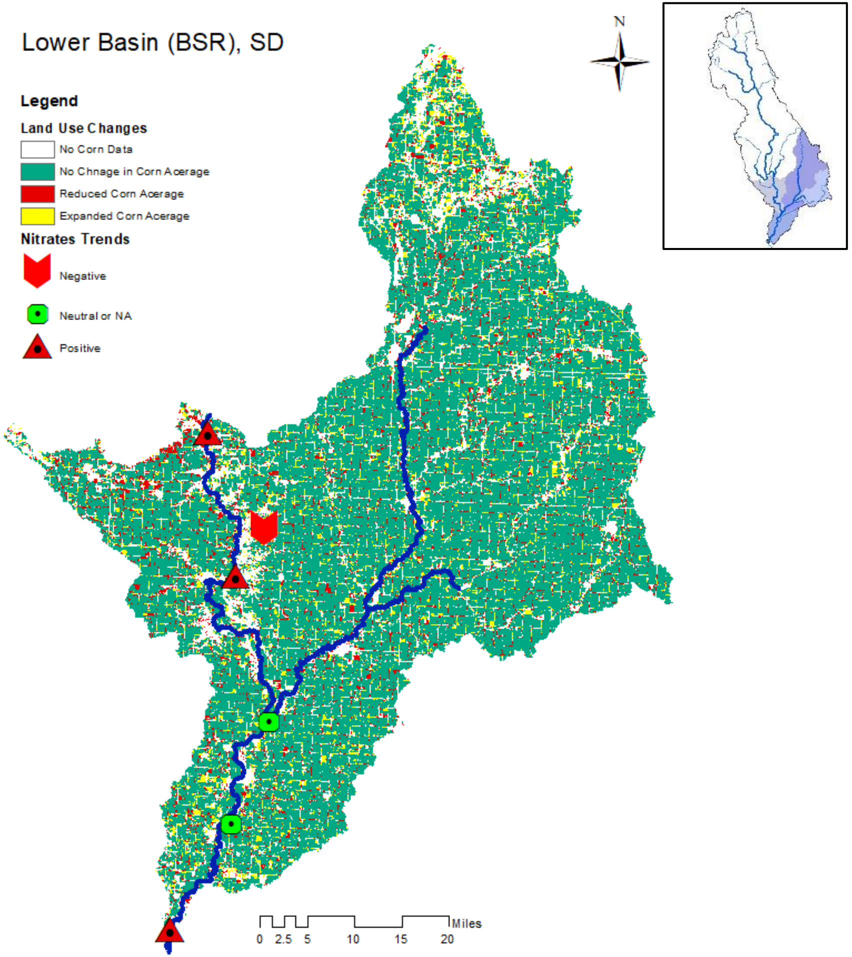
Land Change Ratio

Land uses Parameter for Central Basin	2006	2016	Change Ratio
	Acres in 1000		
Corn/Soy	4306.66	4660.11	1.08
Other Crops	893.83	475.31	0.53
Water	456.72	253.62	0.56
Developed	675.85	503.22	0.74
Grassland	980.18	1418.81	1.45

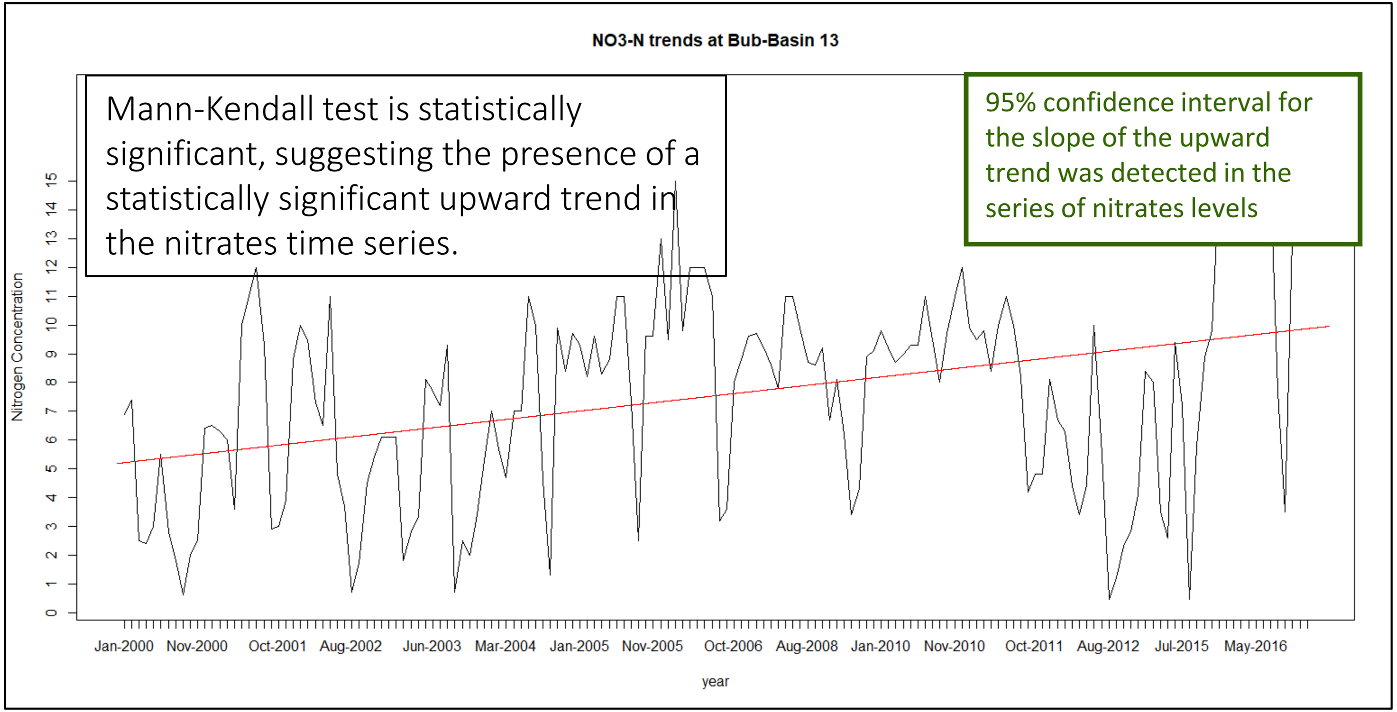


Land Change Ratio

Land uses Parameter for Lower Basin	2006	2016	Change Ratio
	Acres in 1000		
Corn/Soy	4404.48	4409.75	1.00
Other Crops	150.74	127.38	0.85
Water	80.15	117.64	1.47
Developed	446.63	380.49	0.85
Grassland	644.76	687.90	1.07



NO3-N trends



- Mean = 7.54
- sd= 3.74
- max= 18
- min= 0.45
- >10 mg/L = 146

```
tau = 0.228, 2-sided
pvalue =1.8835e-05
```

```
Level Percentile
95% (-0.1735, 0.1703 )
```

Conclusion

- Results are important:
  - likely to provide a better understanding of the role of LULC change to BSR water quality,
  - be important to water supply organizations and farmers in developing improved land management strategies and to ensure clean and affordable public water,
  - the results of the pending court case may alter the Corn Belt Farmland management and Water Acts and could have an impact on EDWDD and other water districts

Acknowledgement

- Department of Geography and Faculties
- Dr. Darrell Napton (Advisor)
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- SDView Mini Grant, SDSU

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Thank you!

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