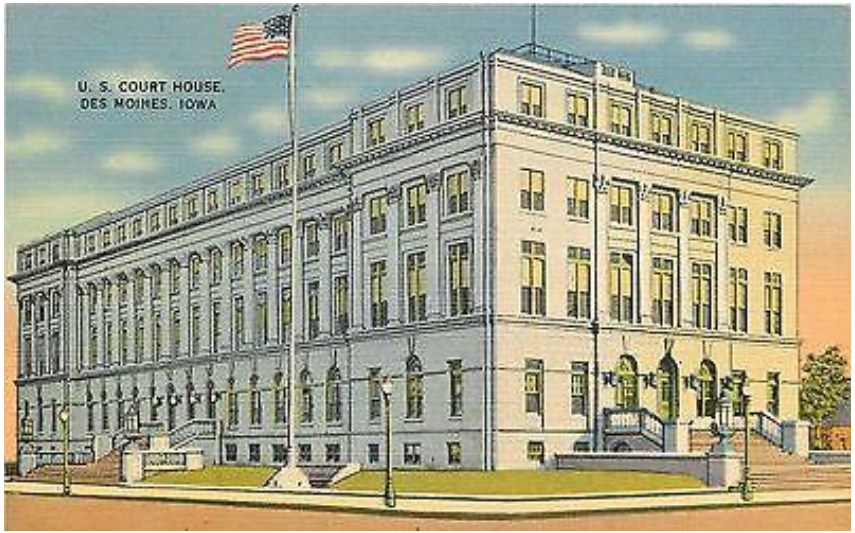
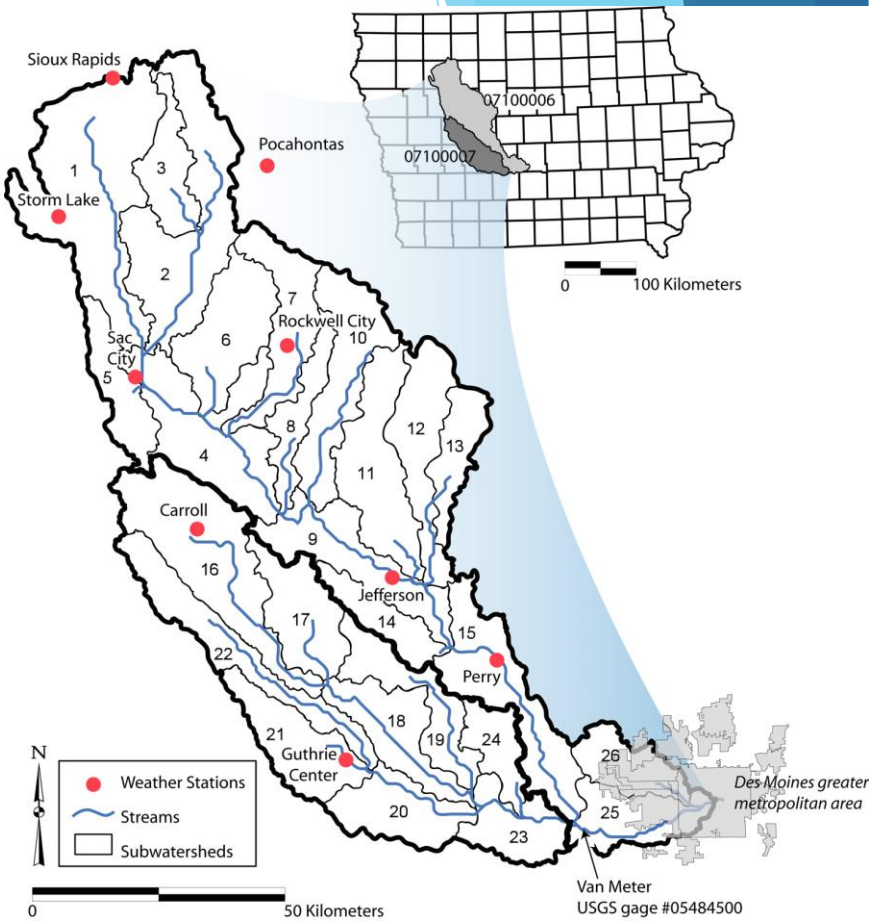
Impacts of Land Use and Land Cover Change on Water Quality in the Big Sioux River Basin: 2007-2015

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

Similar Story



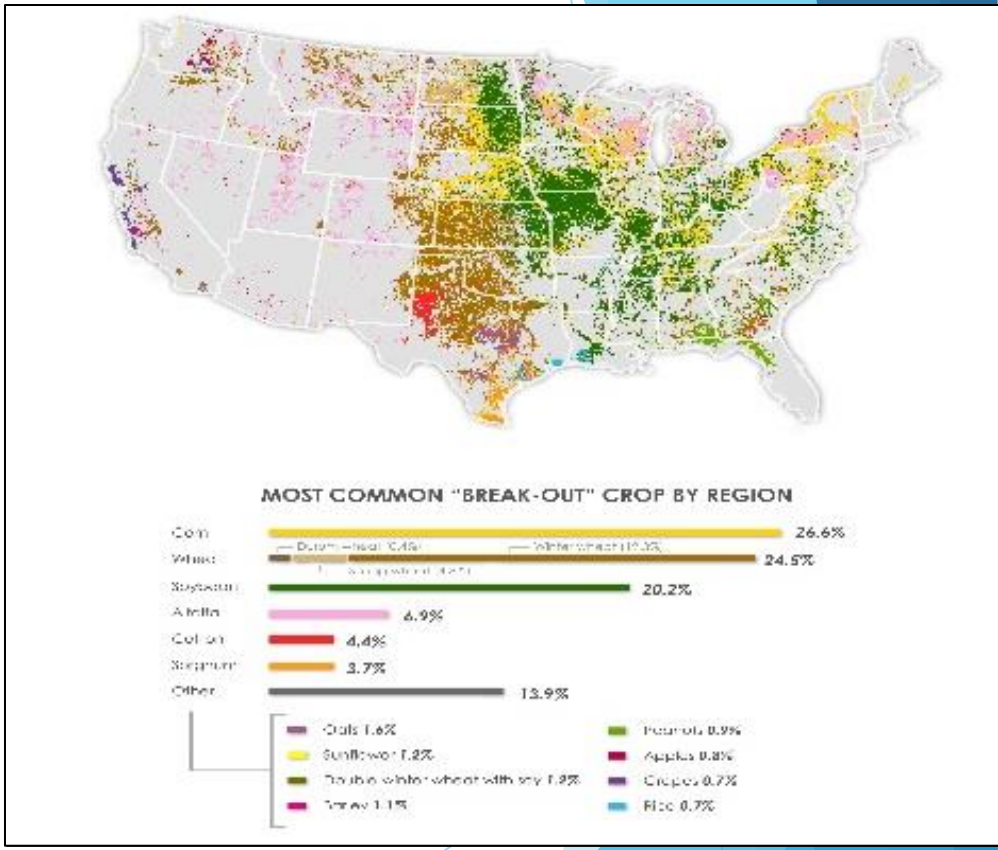


Raccoon River Watershed (Jha et al, 2007)

Stories behind My Story

- **Western Corn Belt Plains Ecoregion**

- More grassland was lost to corn or soybeans.
- The majority of changes is happening along the western edge of the ecoregion.
- Net decline in grass-dominated land cover totaling nearly 530,000 ha in the WCB



Tyler J Lark et al 2015 Environ. Res. Lett. 10 044003 doi:10.1088/1748-9326/10/4/044003

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.

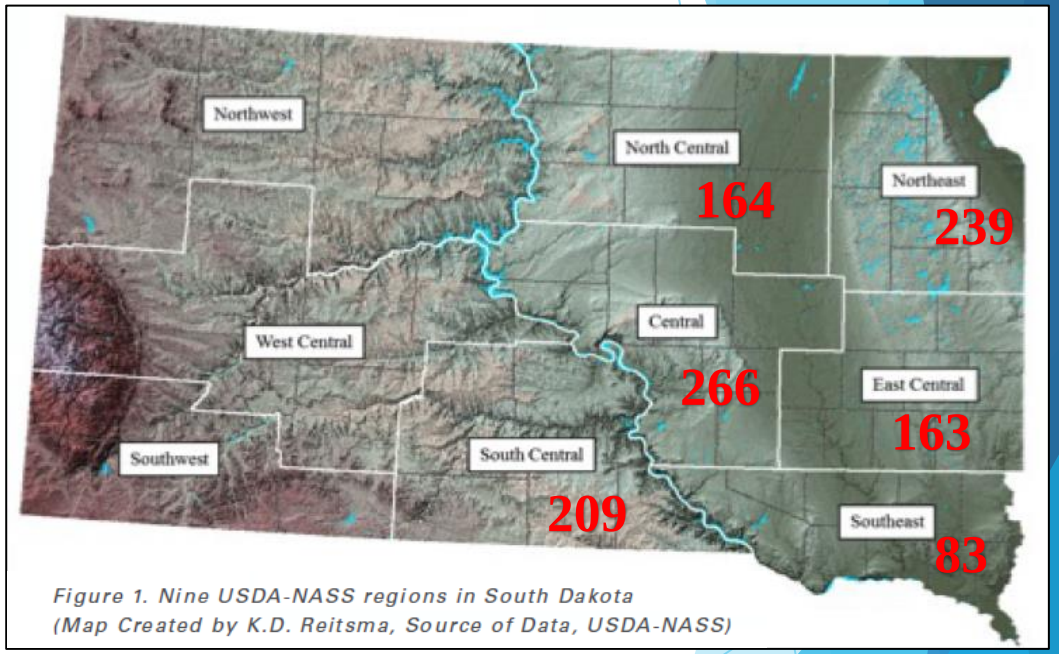


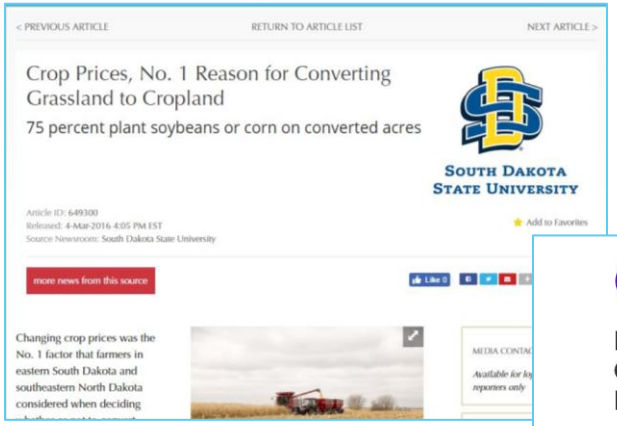
Figure 1. Nine USDA-NASS regions in South Dakota
(Map Created by K.D. Reitsma, Source of Data, USDA-NASS)

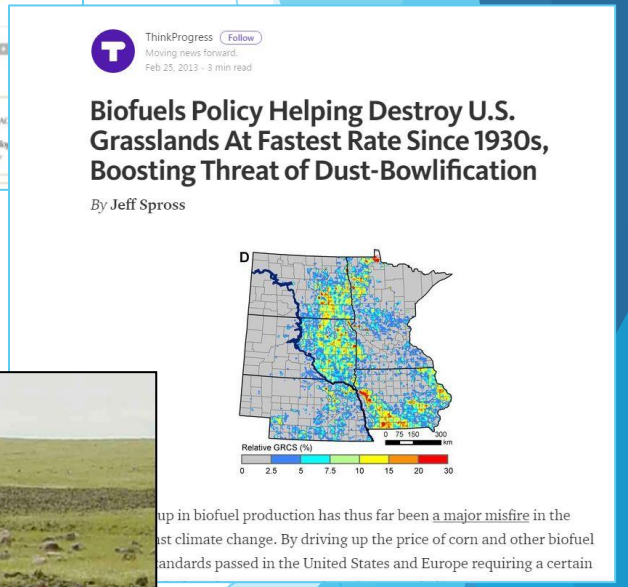
- Changes in the agricultural pattern and use of fertilizer for increasing the productivity have led to an increased quantity of nitrates in the soil.

Framing the story

Driving forces…

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

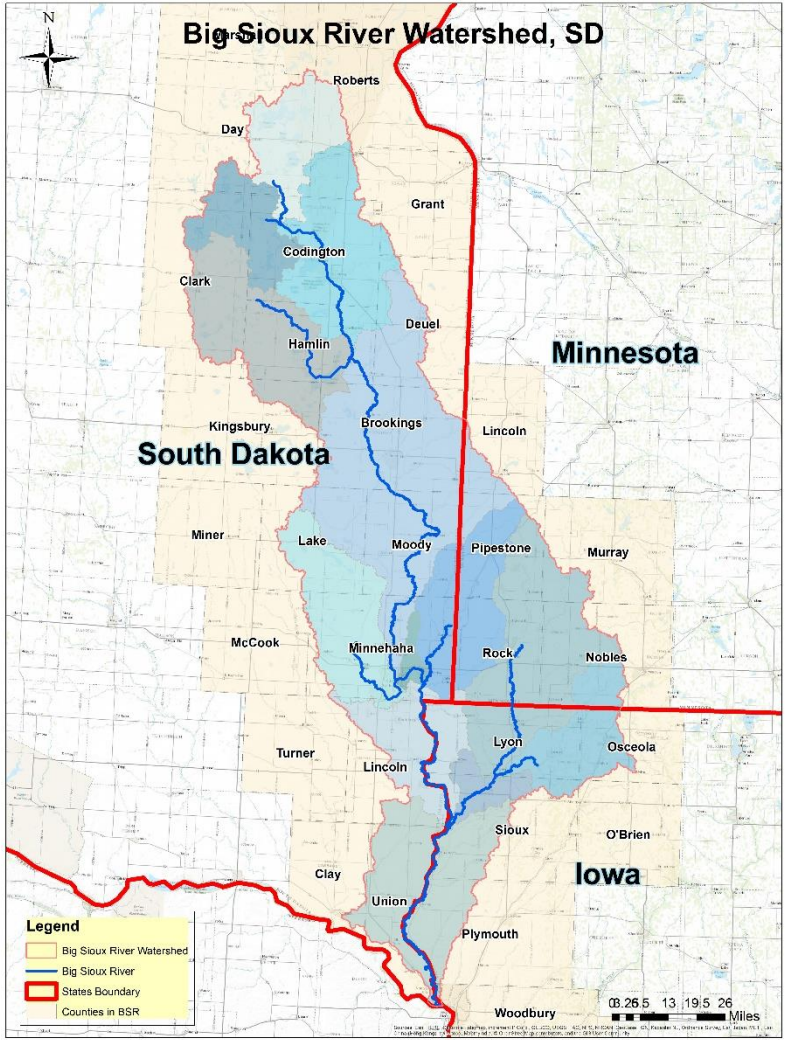




This happened..

Big Sioux River Watershed

- **The Big Sioux River Watershed**
  - Area: 6,000 sq. miles lies in Eastern SD
  - 420 miles long river that begins in Roberts County, SD and flows south to Missouri River in Sioux City, Iowa
  - Historically agricultural state; cattle, corn, soybeans, wheat, and hogs.



Dinesh Shrestha

Big Sioux River Watershed

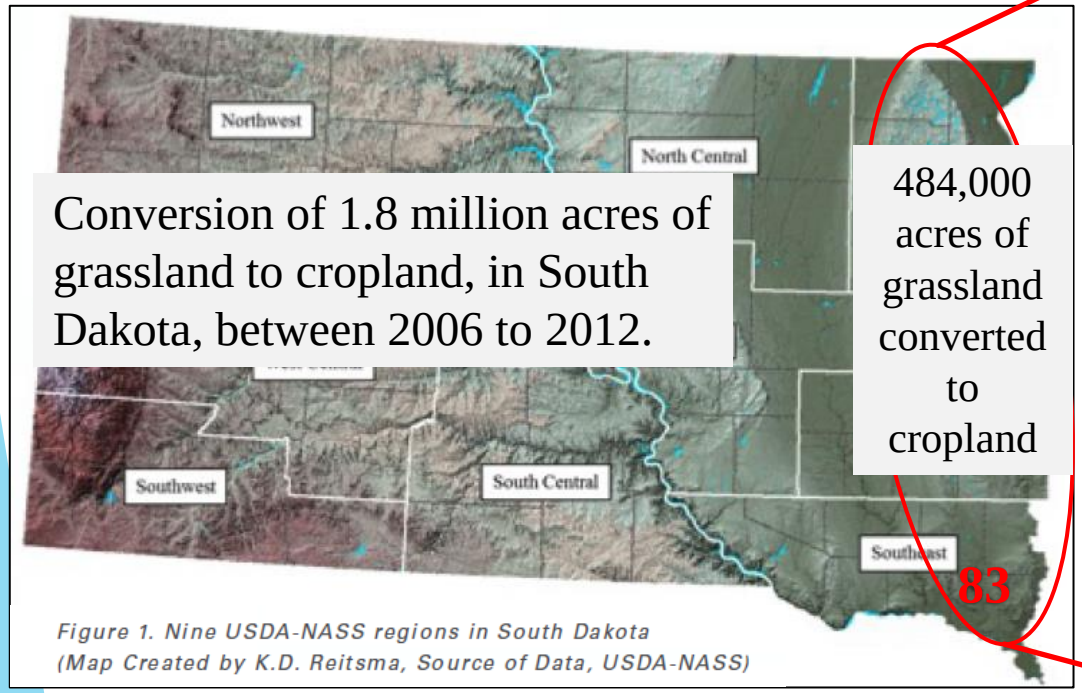
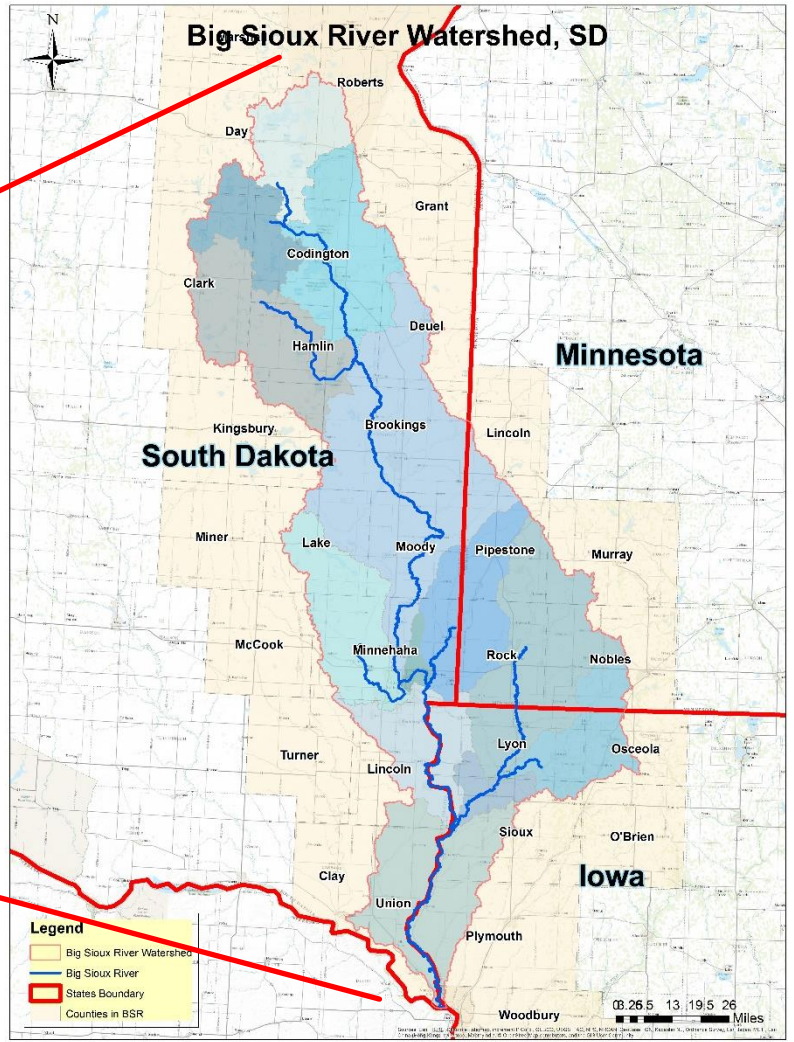


Figure 1. Nine USDA-NASS regions in South Dakota
(Map Created by K.D. Reitsma, Source of Data, USDA-NASS)

Conversion of 1.8 million acres of grassland to cropland, in South Dakota, between 2006 to 2012.

484,000 acres of grassland converted to cropland



Dinesh Shrestha

Research

Topic:

Impacts of Land Use and Land Cover Change on Water Quality in the Big Sioux River Basin: 2007-2015

The objectives of the research are to determine

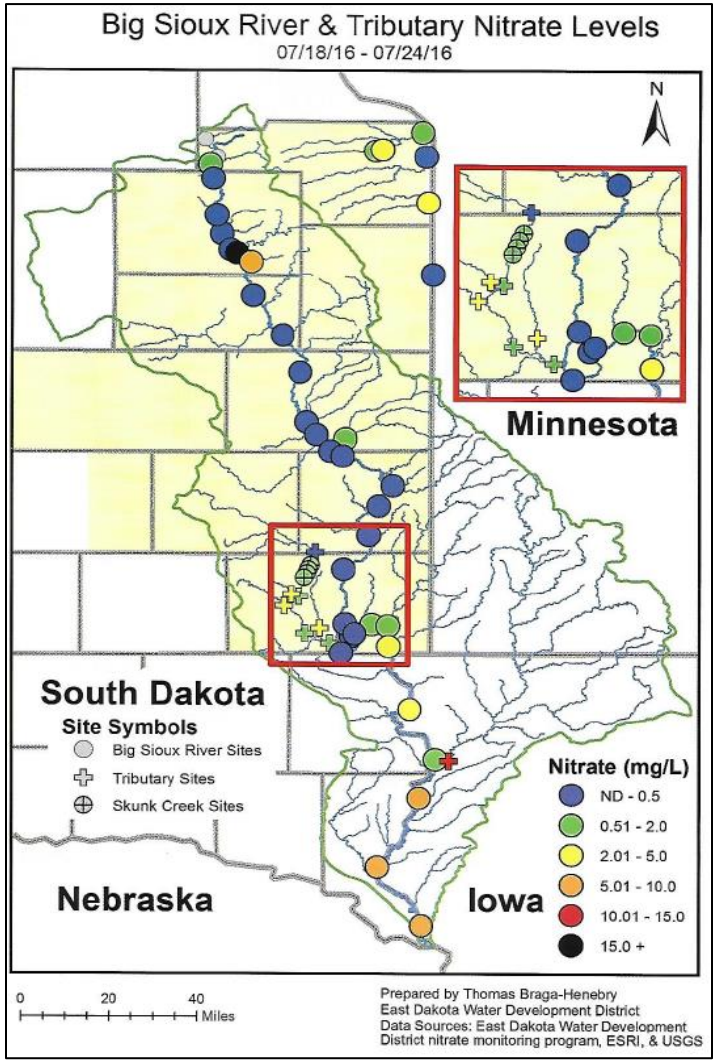
- **(1) Land Use and Land Cover (LULC) change in the Big Sioux River (BSR) watershed,**
- **(2) spatial and temporal trends of nitrogen levels in the BSR, and**
- **(3) determine whether there is a correlation between LULC change and changes in nitrogen levels in the river.**

Methods and Materials

Data Collection

- **Land Use Land Cover Change**
  - National Agricultural Statistics Service (NASS) CropScape-Cropland Data Layer: 2007-2015
  - Field data collection (Field Work)

- **SWAT Analysis**
  - Arc Grid representing a Digital Elevation Model for the Big Sioux River
  - National Land Cover Dataset (NLCD)
  - Soil Data Set – Geospatial Data Gateway
  - Precipitation, Temperature and Weather Datasets
  - **Water quality data from East Dakota Water Development District, SD**



- **SWAT Analysis**
  - Arc Grid representing a Digital Elevation Model for the Big Sioux River
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Methods and Materials

Process

Land Use Land Cover Change

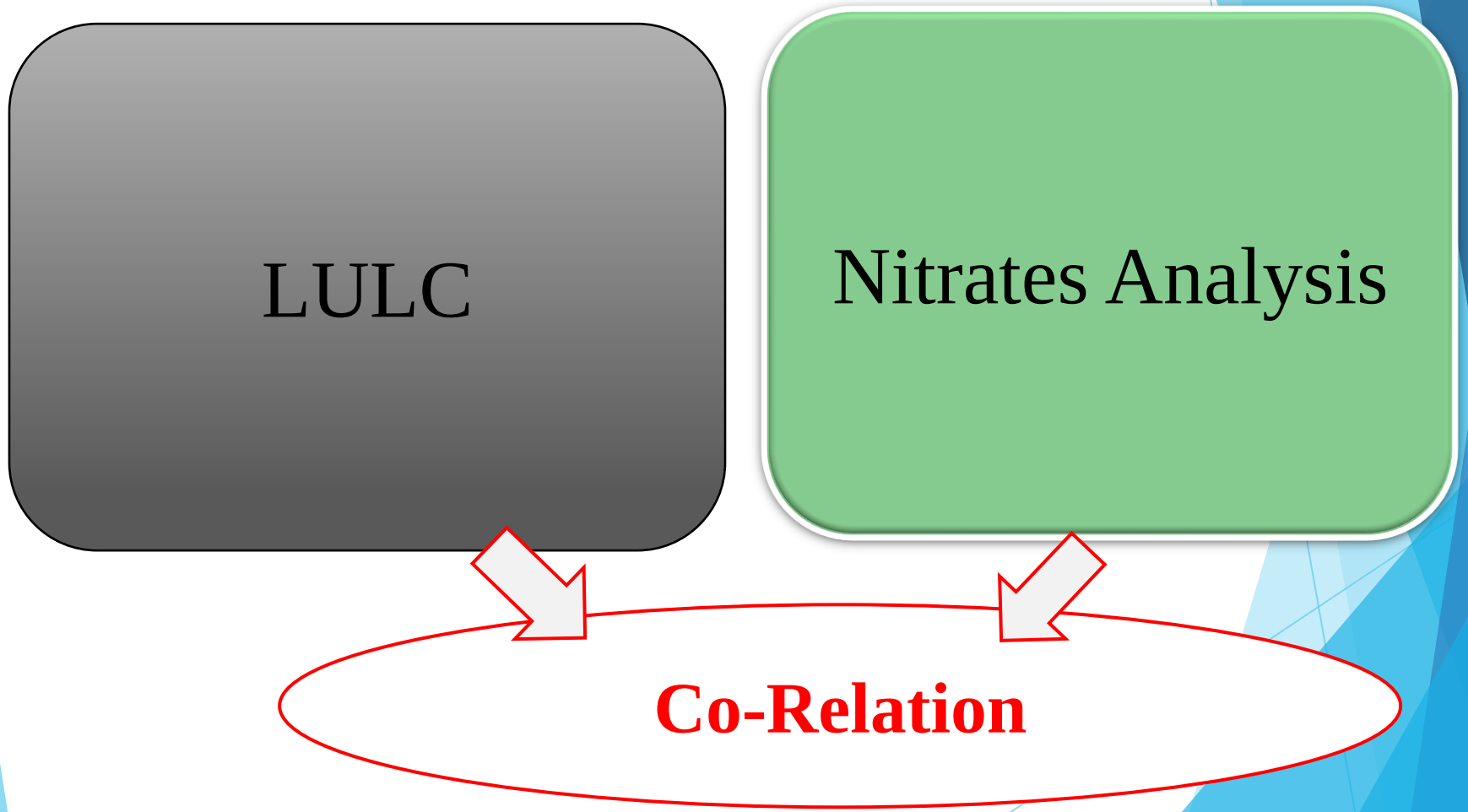
- Reclassification
- Trends of LULC change
- Change Matrix (Contingency Table)

Accuracy Assessment

- Random sampling
- Field data collection
- Verification

SWAT Analysis

- Watershed Delineation
- HRU Definition
- Weather Definition
- SWAT Model run


LULC
Nitrates Analysis
Co-Relation

LULC

CDL Data Analysis

- **Reclassification**
- **Trends of LULC change**
- **Change Matrix (Contingency Table)**

Accuracy Assessment (Filed Visit)

Nitrates Analysis

SWAT Analysis

- **Watershed Delineation**
- **HRU Definition**
- **Weather Definition**
- **SWAT Model run**

Calibration and Validation with Water Quality data from EDWDD

Co-Relation

if LULC change and changes in nitrogen levels in the river has some corelation.

Objective 1

LULC change in the BSR

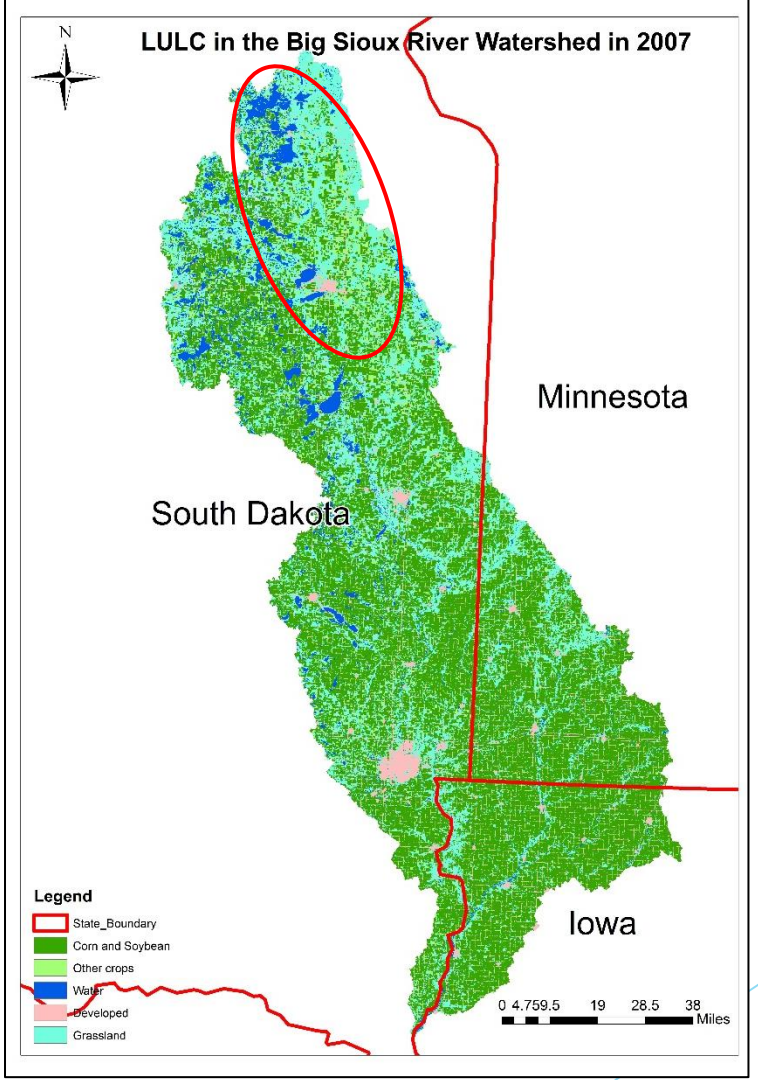
- What was acreage of corn and soybeans in 2007 how did it change in 2015?
- What was acreage of grassland in 2007 how did it change in 2015?
- What acreage of grassland has converted to corn and soybeans?

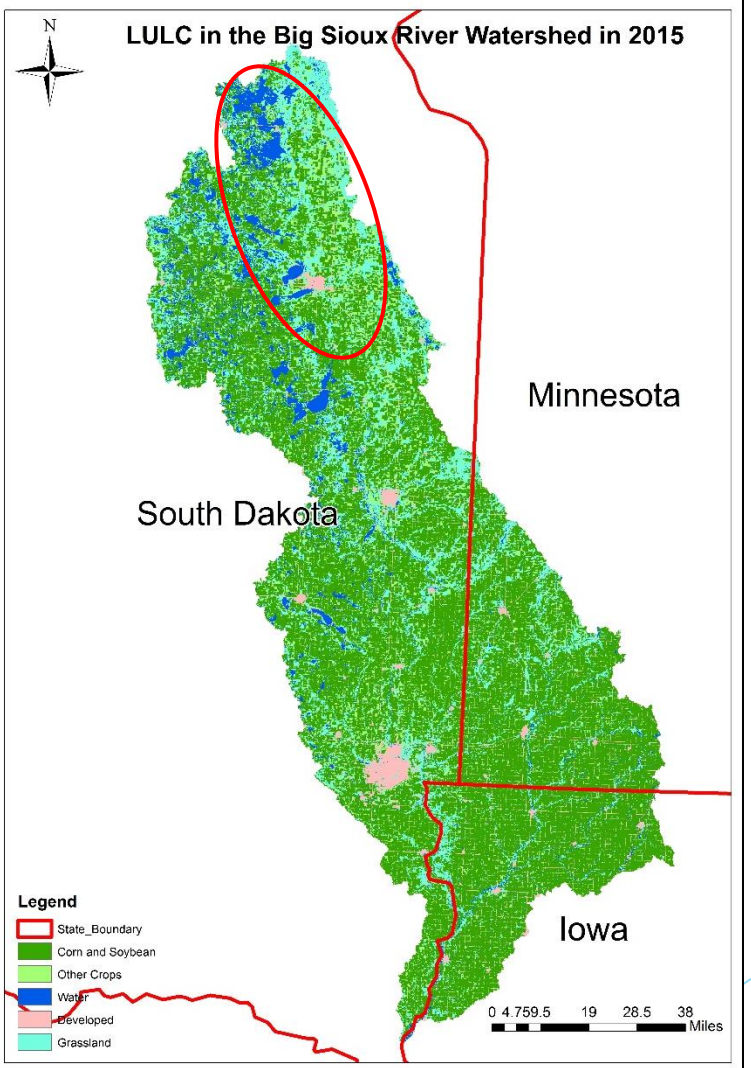
Objective 1:

CDL Analysis

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

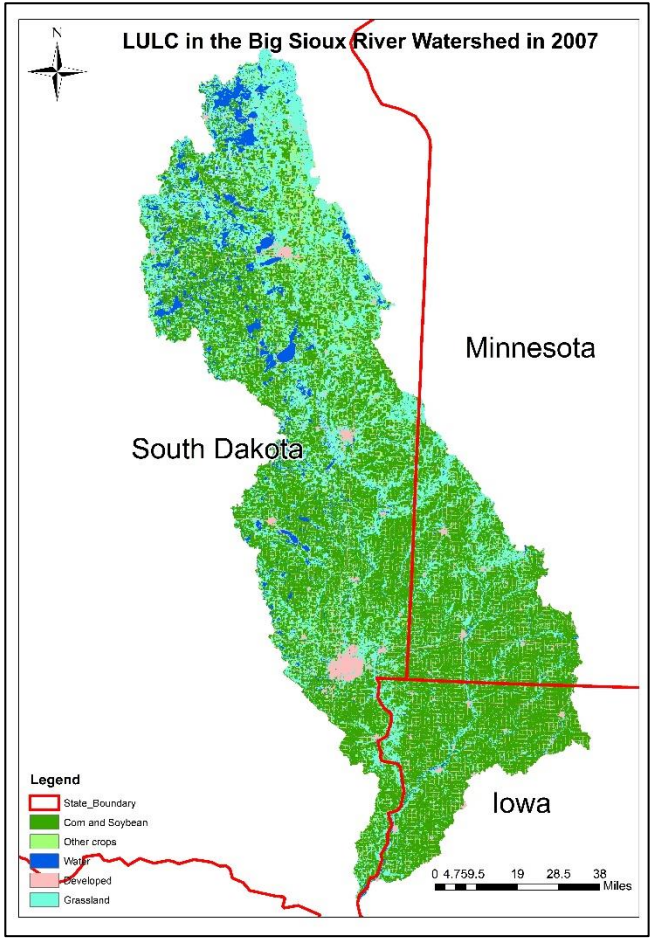
Reclassification Table	
Classes	**Categories**
Corn and Soybeans	Corn and Soybeans
Other Crops	Wheat, Alfalfa, Sorghum, Oats, Millet, Pumpkin, Flaxseed, Potatoes, and other crops.
Water	Water, Wetlands
Developed	Open space, low/medium/high density
Grassland	Forest, Switchgrass, Grass/Pasture, Fruit Trees,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

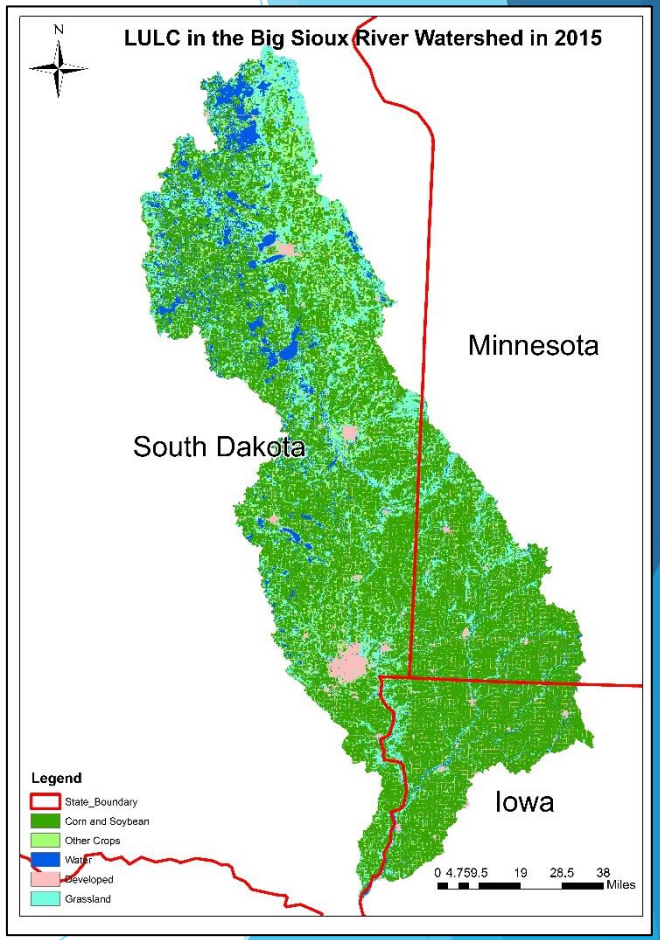

LULC in the Big Sioux River Watershed in 2007
N
Minnesota
South Dakota
Iowa
Legend
State_Boundary
Corn and Soybean
Other crops
Water
Developed
Grassland
0 4.759.5 19 28.5 38
Miles


LULC in the Big Sioux River Watershed in 2015
N
Minnesota
South Dakota
Iowa
Legend
State_Boundary
Corn and Soybean
Other Crops
Water
Developed
Grassland
0 4.759.5 19 28.5 38
Miles

Corn and Soybeans increased by **1.37 million acres**

Grassland decreased by **1.52 million acres**

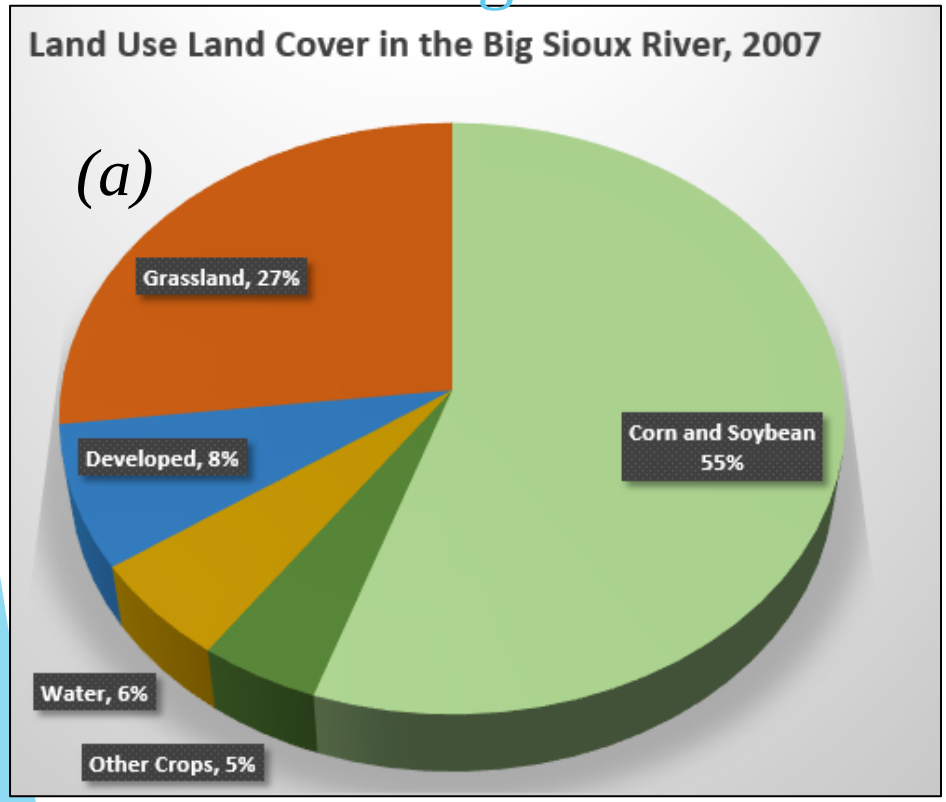


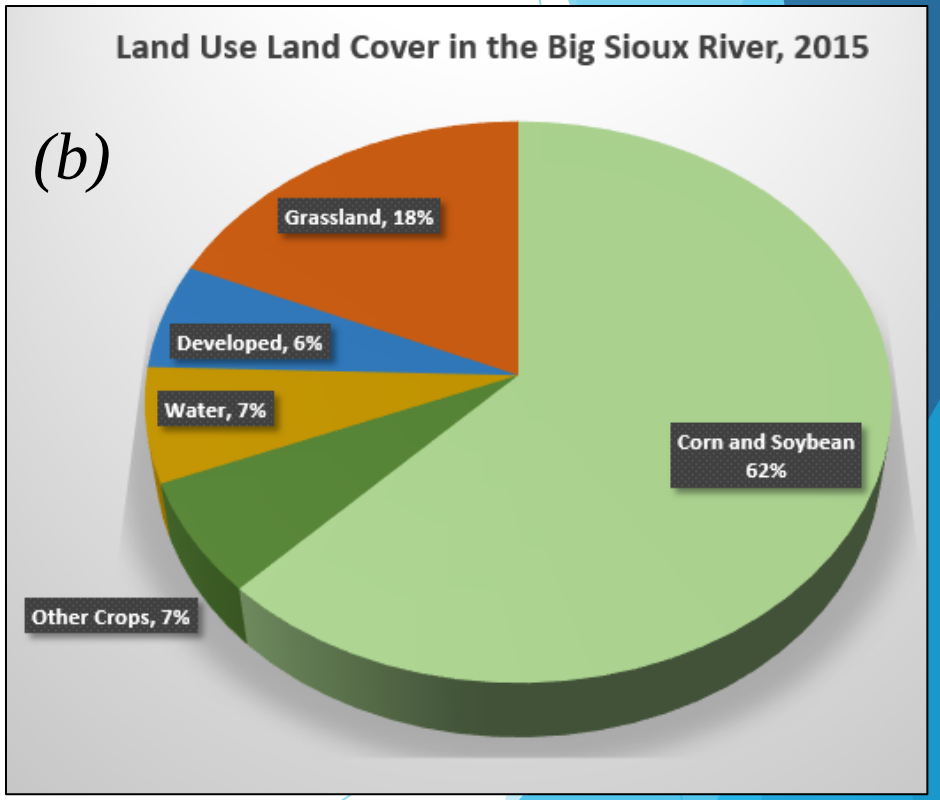


Acreage Coverage and Change

	Acreage in 2007		Acreage in 2015		Acreage Change
	Acreage	% Change	Acreage	% Change	
Corn and Soybean	10,185,100	55%	11,559,200	62%	**1,374,100**
Other Crops	836,478	5%	1,214,840	7%	**378,362**
Water	1,029,580	6%	1,225,250	7%	**195,670**
Developed Area	1,445,020	8%	1,127,710	6%	**(317,310)**
Grassland	4,948,420	27%	3,422,500	18%	**(1,525,920)**
Total	18,444,598	100	18,549,500	100	

LULC Change



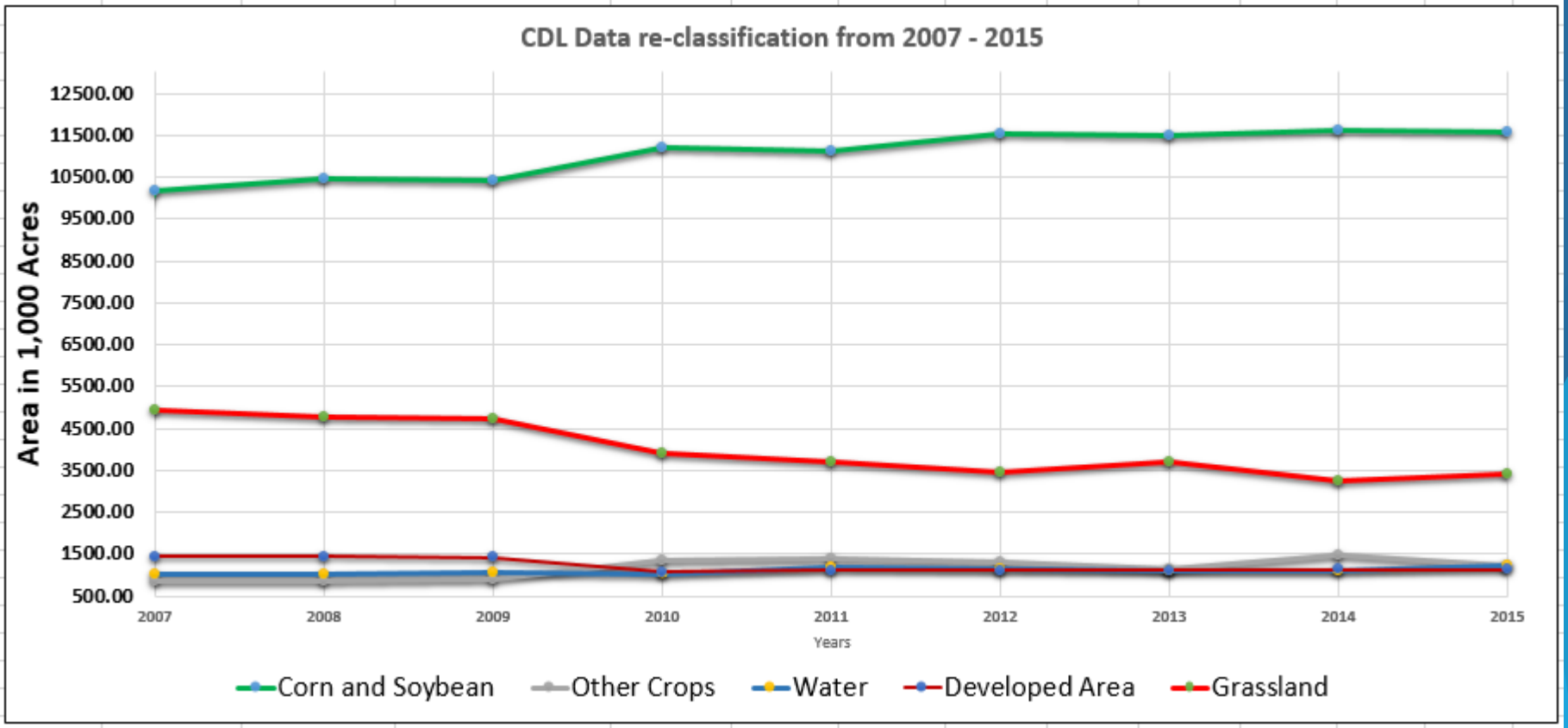


Pie charts showing the percentage of land use and land cover in the Big Sioux River in (a) 2007, and (b) 2015.

Land Use Land Cover Change

- Reclassification
- Trend of LULC change
- Change Matrix

Objective 1 contd…



Land Use Land Cover Change

- Reclassification
- Trend of LULC change
- Change Matrix

Objective 1 contd…

Table: CDL Data Reclassification into 5 major class types, area in 1,000 of acres, from 2007 to 2015.

		2015	2015	2015	2015	2015	
		Corn and Soybean	Other Crops	Water	Developed	Grassland	Total
2007	Corn and Soybean	[illegible]	2.88	0.44	0.84	1.25	55.22
2007	Other Crops	3.12	1.04	0.06	0.07	[illegible]	4.53
2007	Water	0.51	0.28	4.22	0.07	0.52	5.58
2007	Developed	1.98	0.23	0.21	[illegible]	1.11	7.83
2007	Grassland	7.08	2.13	[illegible]	0.82	15.16	26.83
	Total	[illegible]	6.55	6.56	6.11	18.29	100.00

Objective 1 contd…

CDL Analysis

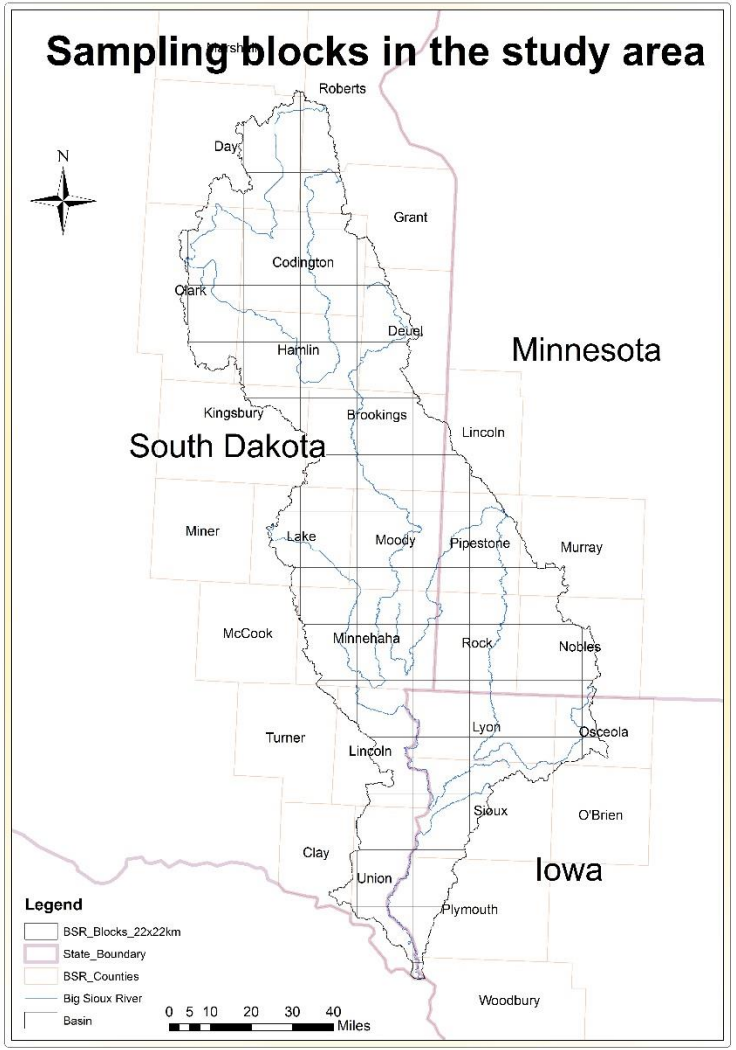
- Reclassification
- Trend of LULC change
- Change Matrix (Contingency Table)

Accuracy Assessment (Field Data Collection)

- Random sampling
- Field data collection
- Verification

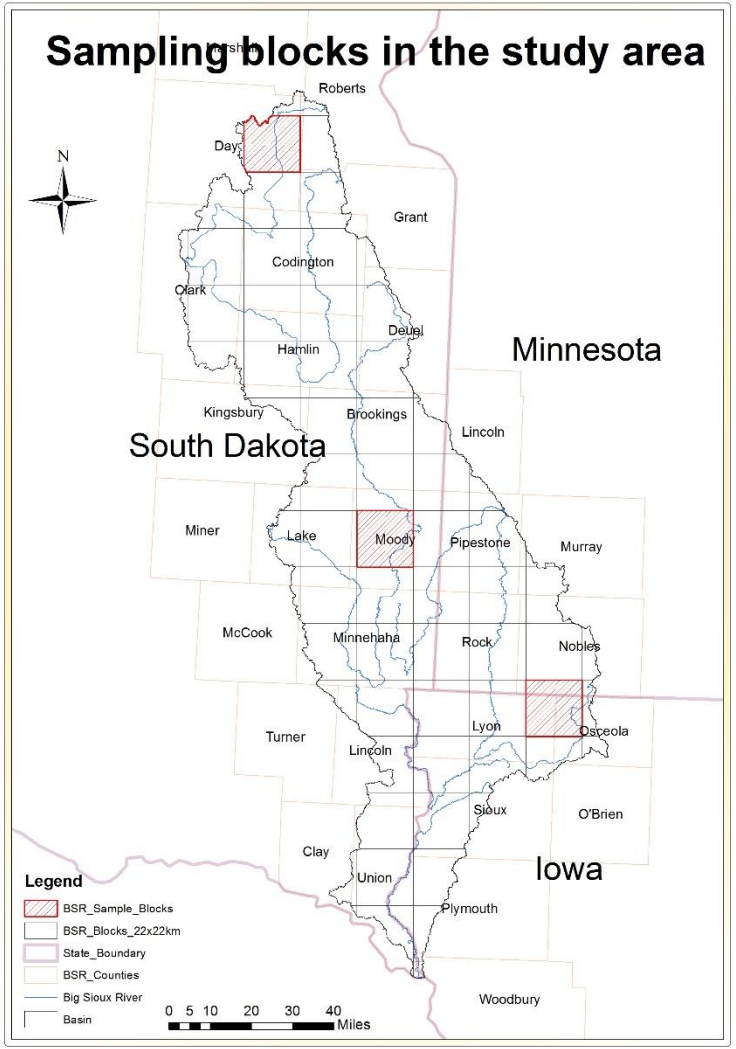
Objective 1 (Accuracy) contd…

- Divided into 52 sample blocks 22X22 km wide.
- Select 3 sample blocks randomly at a sampling intensity of 5%, (5% of 52 = 2.6 blocks == 3).
- Each sample block should have at least 30 training sample points for each class = 5X30 = 150) per sample block.
- Altogether, I should have 450 training samples.



Objective 1 (Accuracy) contd…

- Use Google Earth or ArcGIS online for accuracy assessment of the sample training for the classes Water and Developed
- For classes such as Corn and Soybeans, Other crops, and Grassland use field data to verify.
- Use Global Positioning System (GPS) to geo-locate the training points.
- Also take the photographs.



Objective 2

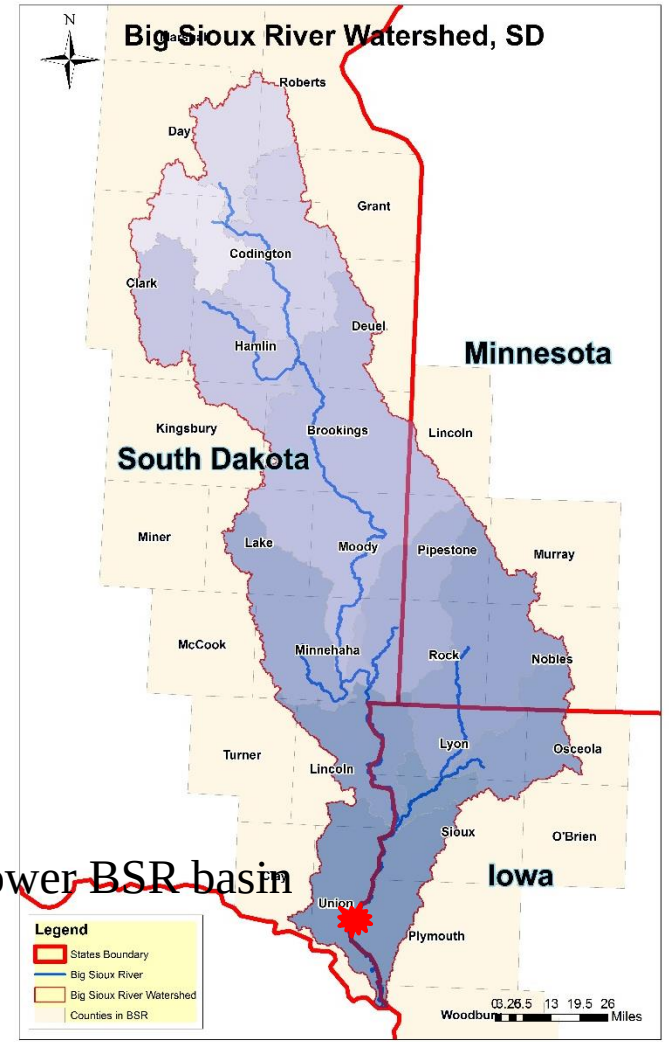
Trends of nitrogen levels in the BSR

- What was nitrogen level in water in the BSR in 2007 how did it change in 2015?
- Were there any changes in fertilizer application in the cropland?
- How has the nitrogen fertilizer usage changed from 2007 to 2015?
- What is the trend of nitrogen leaching from soil to water?

Objective 2:

SWAT Analysis

- Watershed Delineation
- HRU Definition
- Weather Definition
- SWAT Model run



Station WQM32 at lower BSR basin

Objective 2:

SWAT Analysis

- Watershed Delineation
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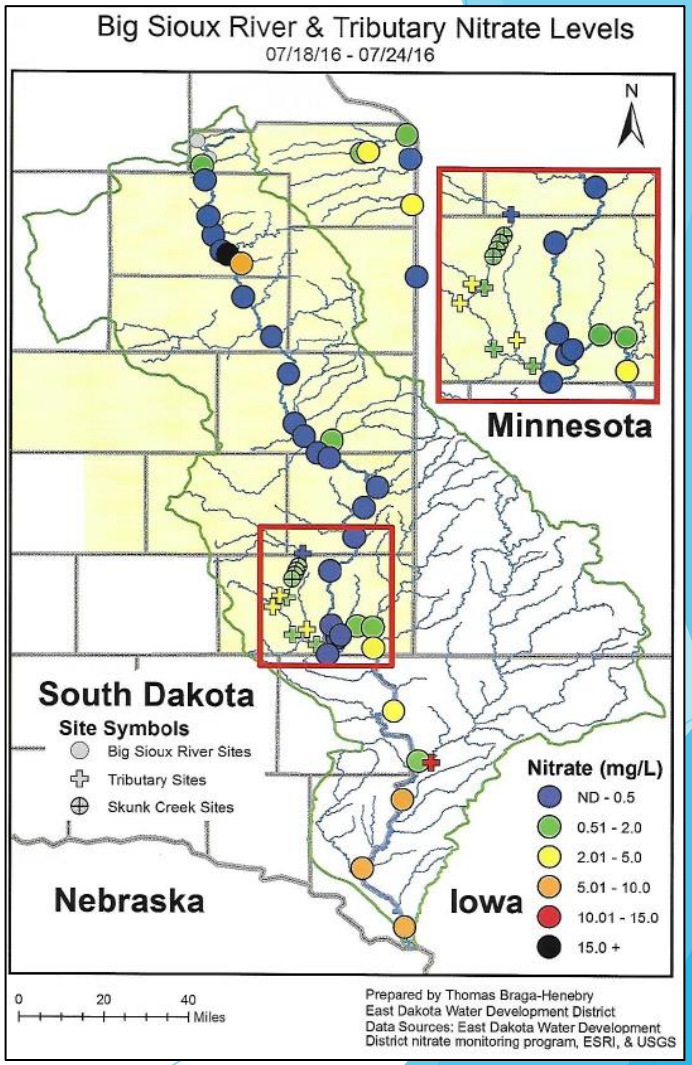
- Weather Definition
- SWAT Model run



Expected Output

- Determine the pattern on how the land cover has changed from 2007-2015.
  - (1) maps showing the geographical distribution where LULC changes occurred,
  - (2) the graphs showing the trends of LULC change,
  - (3) the pie-charts showing what percentage land cover has changed, and
  - (4) the matrix (contingency) table to show the land cover in 2007 and how they have changed in 2015.
- Determine how the nitrogen levels in the river has changed from 2007-2015.
- Determine whether there is a correlation between the LULC change and change in nitrogen levels in the river.

Conclusion

- Results are important:
  - the results of the pending court case may alter the Corn Belt Farmland management and Water Acts,
  - could have an impact on EDWDD and other water districts
  - 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 to ensure that South Dakotan continue to have access to clean and affordable public water.

Acknowledgement

- **Jay Gilbertson, East Dakota Water Development District**
- **Dr. Darrell Napton (Advisor)**
- **Department of Geography**

References

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- Wright, Christopher K., and Michael C. Wimberly. 2013. Recent land use change in the Western Corn Belt threatens grasslands and wetlands. *Proceedings of the National Academy of Sciences* 110 (10): 4134-4139.

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Thank you!

Dinesh Shrestha, Department of Geography, SDSU
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Note: This proposal was awarded with Sigma Xi Graduate Student Research (Proposal) Award, 2017