WATER QUALITY IMPLICATIONS OF LAND CONVERSION TO CORN-SOY CULTIVATION IN NORTHEAST KANSAS

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Abstract

With growing biofuel production in the Midwestern United States, the Corn Belt could be said to have expanded to include northeastern Kansas. As the other regions of Corn Belt become saturated with respect to ethanol biorefineries and available corn grain, nearby Kansas remains an area with potential for expansion of ethanol production. Though northeastern Kansas has also experienced an increase in agricultural production in recent decades, the impact of corn production increase on surface water bodies at watershed scale is still unknown. Here, we are studying the impact of cropland intensification and expansion on water quality and associated sustainability indicators in this region. In our project, we are working to analyze the trend of agricultural production increase and correlate different water quality parameters to understand its effect.

Study Area and Method

As a representative of this region's existing environmental problem, Delaware River Watershed is selected which experienced corn land intensification in recent decades. Perry Lake, located downstream of this watershed, is a regionally important reservoir with sedimentation and eutrophication problems.

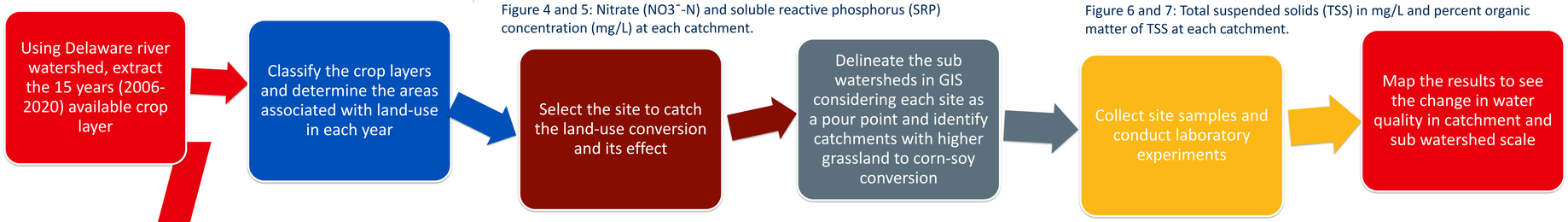
We have used the crop data layer available from the United States Department of Agriculture (USDA) to determine the land use change that occurred in Delaware River Watershed from 2006 to 2020. To catch the associated effect on water quality, 30 sites were selected based on land-use change intensity and accessibility. With the water samples collected in Summer 2021, different water quality indicators are determined using the following instruments: Spectrophotometer, TOC Combustion Analyzer and Ion Chromatography.

Research questions

We are investigating answers for the following research questions:

1. How correlated are spatial and temporal patterns in water quality parameters with patterns in grass to crop land conversion over the last 15 years??
2. What is the extent of biofuel crop production in the region that could be sustainable?

Workflow



Preliminary Results

The results that we obtained can be classified into two distinct segments. One is significant increase in corn-soy production and subsequent conversion of grassland/pasture to crops related to biofuel production. Another is water quality parameters correlated to land-use conversion.

From 2006 to 2020 (2013 Land-use data was discarded for some unusual values), we have seen a steady increase in corn-soy production (Figure 1) and although it is not steady, there occurred a 20% reduction in grassland. The 15% increase in corn-soy cultivation area is mostly attributed to grassland to crop conversion at the northern edge of the watershed (Figure 2 and 3) which is also more susceptible for water quality degradation (Figure 4, 5, and 6).

The nitrate (NO_3^--N) and soluble reactive phosphorus (SRP) concentrations are greater (Figure 4 and 5) in the upland portion of the watershed where the intensity of corn-soy production is highest. The percent organic matter for suspended solids (OM) is also greatest in the agricultural dominated northern edge of the watershed as well as in sites adjacent to the Perry Lake reservoir (Figure 7). Total suspended solids concentration is higher in the middle region of the watershed where the streamlines from agricultural land converge (Figure 6).

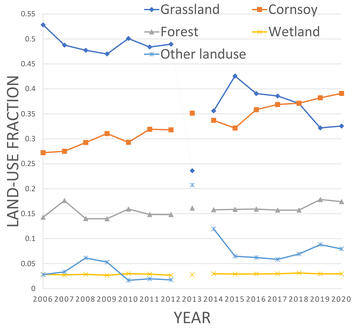


Figure 1: Fraction of land-use change from 2006 to 2020

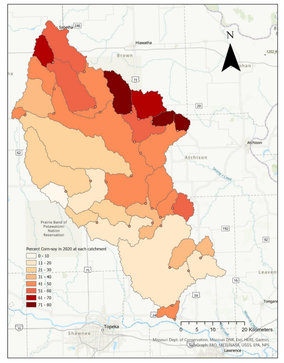


Figure 2: Percent land used for corn-soy cultivation within catchment.

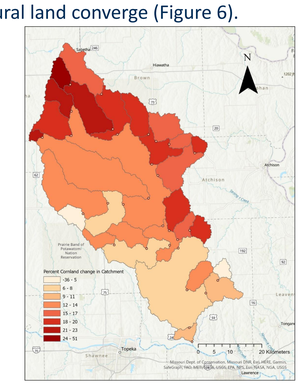


Figure 3: Percent increase in corn-soy cultivation.

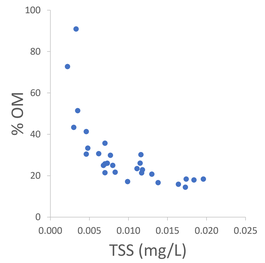
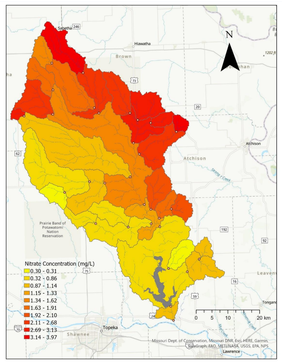


Figure 8: Percent organic matter for suspended solids decreased as total suspended solid concentration increased across sites.

- Land use changes over the past 15 years have resulted in a 20% reduction in grassland, and a 15% increase in corn-soy rotational cultivation.
- Nitrate and SRP concentrations are higher where site catchments contain the highest corn-soy production and highest rates of land use conversion



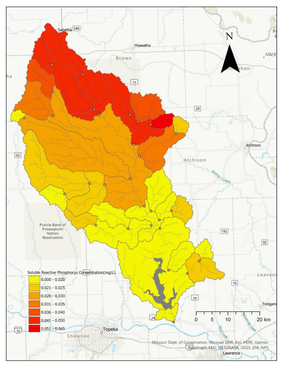
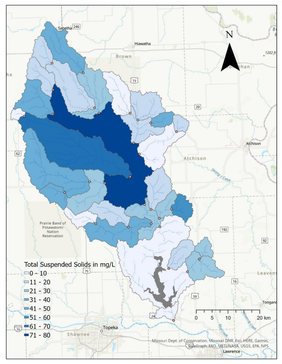


Figure 4 and 5: Nitrate (NO_3^--N) and soluble reactive phosphorus (SRP) concentration (mg/L) at each catchment.



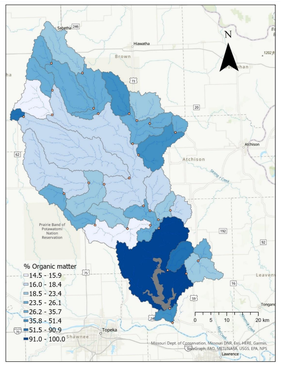


Figure 6 and 7: Total suspended solids (TSS) in mg/L and percent organic matter of TSS at each catchment.

Nemaha and Brown County which are in the northern part of this watershed are the most agriculturally intensive and high corn-soy production in this area is proportionally correlated to higher nitrate and SRP concentrations. TSS concentration and percent organic matter presence at each catchment are inversely correlated (Figure 8). The catchment areas with more TSS concentrations (at places where streamlines from agricultural land converge) show lower percent OM values. Conversely, the Perry Lake reservoir region has higher percent OM and lower TSS concentration.

Conclusions

The effect of biofuel production expansion and intensification is evident in the results found from different water quality parameters. But it doesn't necessarily answer to all our questions. Up to this point, we are certain about more of the grasslands have converted to cornlands and there is an effect of agricultural production on water quality indicators in catchment and sub watershed scale.

Future Directions

Seasonal variations in water quality will be assessed with additional sampling campaigns in order to understand the impact of land-use conversion on water quality.

Field data along with publicly available monitoring data will be used to develop a watershed water quality model using the Soil Water and Assessment Tool (SWAT) and simulate the effect of biofuel expansion intensity on water quality and potentially identify locations or thresholds of land conversion that do not severely affect water quality. If larger areas of land use conversion are possible without adversely affecting the watershed environmentally, we can reach to a conclusion that Kansas can be the next potential place for biofuel generation.

References

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[2] Green TR, Kipka H, David O, McMaster GS. Where is the USA Corn Belt, and how is it changing? Sci Total Environ. 2018 Mar 15;618:1613-1618. DOI: 10.1016/j.scitotenv.2017.09.325.

[3] U.S. Department of Agriculture (USDA), 2020. Cropscape – Cropland Data Layer https://nassgeodata.gmu.edu/CropScape/ (accessed 11/07/2021)

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