Assessing the Relationship Between Groundwater and AFOs in the Loup Watershed, NE

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Introduction

- Animal feeding operations (AFOs) generate manure and wastewater that contain nitrogen and phosphorus (P), which have the potential to make their way into groundwater. Excess amounts of these nutrients in groundwater leads to a variety of environmental and health concerns (Ward et al., 2005).
- Previous studies have found elevated nitrate concentrations in wells closer to AFOs, but there are many variables involved, including fertilizer application (Lockhart et al., 2013, Exner and Spalding, 1994).
- The **goal** of this study was to determine the relationship between AFOs and nitrate found in groundwater in the Loup Watershed, Nebraska.
- P data was not available in this study area. However, dissolved phosphorus follows similar flow paths to nitrate. Because there is more phosphate in manure than there is nitrate, if we see a correlation between AFOs and elevated nitrate, we may see a correlation between AFOs and elevated phosphate.

Study Area

Fig. 1. The Loup Watershed in Nebraska, USA, covers an area of about 4,000 square km. Nebraska is the 4th-highest livestock & poultry manure-producing state in the US, producing 5.3% of US manure, ~ 59 million tons in 2007 (EPA, 2013).

Methods

- Obtained nitrate measurements from groundwater wells in the watershed, sampled from 1990 - 2019, and found average N for each well, resulting in 1,552 observations
- Obtained publicly-available AFO point location data for the watershed, and used a geographic information system (GIS) to conduct ground-truthing (the process of moving each point to the exact location of the animal shed)
- Computed the number of AFOS within 2 and 5-kilometer circular buffers around each well (distance chosen based on previous values used in the groundwater literature)
- Added several explanatory variables including well depth, land use, elevation, and soil hydraulic conductivity values in order to consider aspects of the the well environment
- Used stepwise regression to select the variables to include in model to evaluate AFO measures and log nitrate, and performed quantile regression when linearity assumption was not met

Results

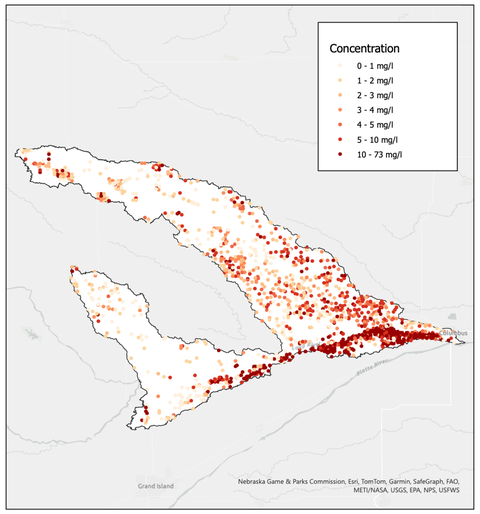

Fig. 2. Nitrate measurements for well locations in the Loup Watershed, with the darkest shade being all wells above the EPA nitrate limit of 10 mg/L

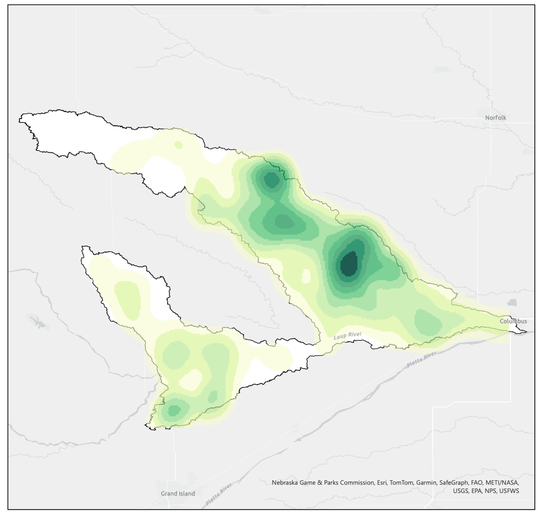

Fig. 3. Heat map for AFO locations in the Loup Watershed, with the darkest shade being the densest concentration of AFOs in the region

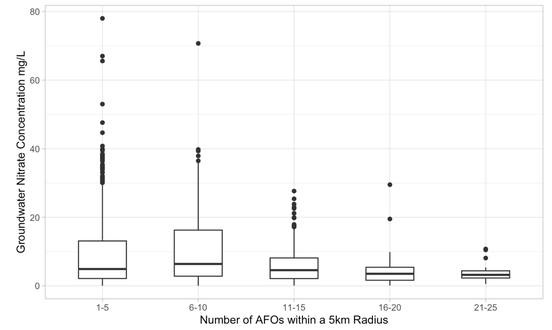

Fig. 4. Box plots of groundwater nitrate concentration by number of AFOs within a 5km radius of each well, grouped into sets of 5

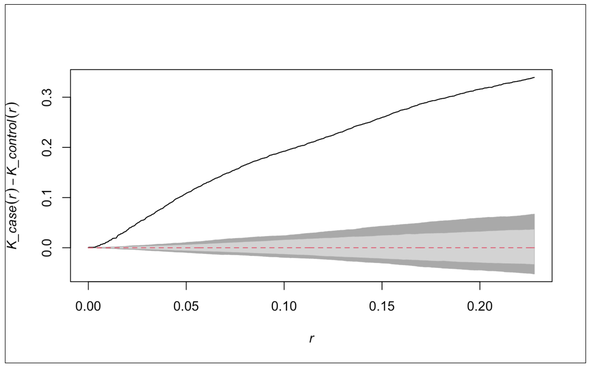

Fig. 5. Test for spatial clustering of high-nitrate wells relative to low-nitrate wells. The y-axis is the difference in *K*-functions between high and low nitrate wells. The gray area is an envelope that reflects the variability in the difference in *K*-functions assuming high-nitrate and low-nitrate wells have the same spatial distribution, with the CI in light grey

Table 1. Results from quantile regression for the relationship between AFO measures and log nitrate (mg/L) in wells in the Loup Watershed, NE

Variable	Quantiles	Coefficient	Standard error	P-value	ANOVA p-value
Total AFOS within 2 km	Q2: [1]	-0.02	0.03	0.496	
	Q3: [2]	-0.03	0.017	0.0618	
	Q4: [3, 10]	-0.09	0.03	0.002*	0.05
Total AFOS Within 5 km	Q2: [1, 5]	0.0023	0.009	0.8009	
	Q3: [6, 8]	-0.015	0.005	0.0088*	
	Q4: [9, 25]	-0.04	0.009	<0.001*	0.08

Discussion

- Neither stepwise-selected regression model nor quantile regression show that number of AFOs within either a 2km or 5km buffer can predict nitrate concentration with statistical significance
- Spatial clustering of high-nitrate wells was significant (p = 0.01). The difference in the *K*-functions between high-nitrate and low-nitrate wells was larger than expected under the null hypothesis of equal distribution for high-nitrate and low-nitrate wells

Next steps:

- Finding animal counts at each AFO, which may be a much better indicator of nitrate in wells
- Looking at further variables: precipitation, the distance from wells to manure application sites, as well as potential variable interactions

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References

Access my references using the QR Code to the right

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