TRACING SUSPENDED SEDIMENT IN AN ANTHROPOGENICALLY INFLUENCED WATERSHED WITH NUMEROUS CHANGES TO LAND USAGE AND STREAM MORPHOLOGY

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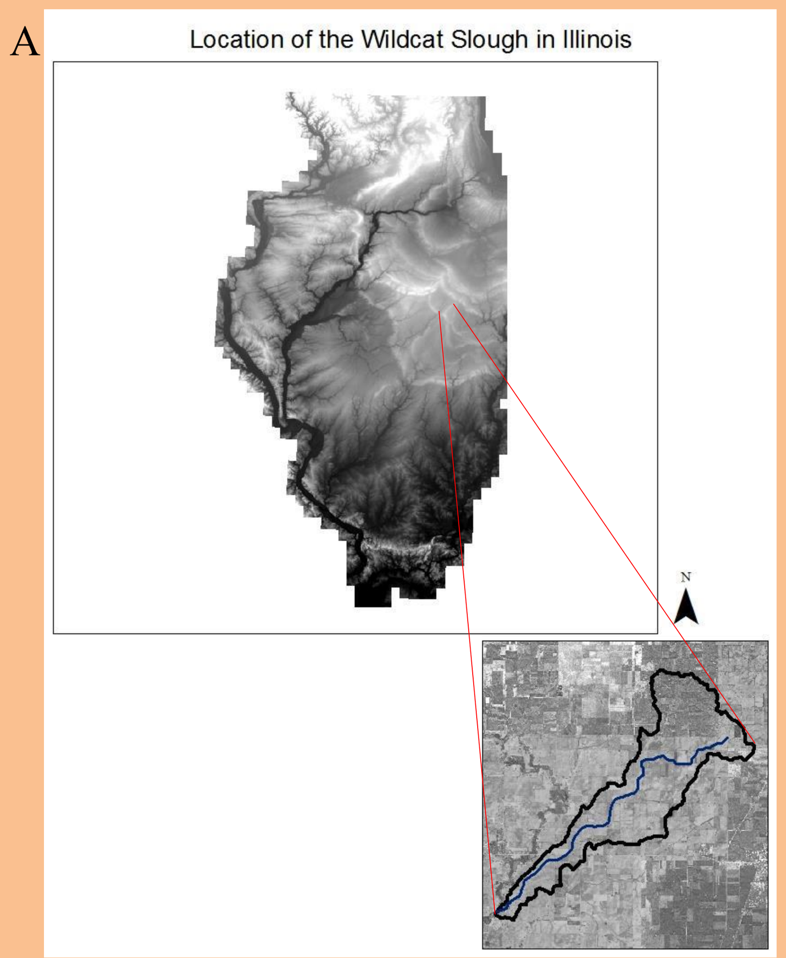
Abstract

Nutrient loading in the Upper Mississippi River Basin has led to concentrations of nitrate that exceeds EPA water quality standards and concentrations of phosphorous which promote algal growth in many headwater streams and has led to recent hypoxia in the Gulf of Mexico. These high nutrient levels are due to long term fertilizer application and tile drainage networks which connect upland sediments to the stream. This study focuses on the Wildcat Slough, a headwater river in central Illinois with a 61.3km^2 watershed primarily used for agriculture, but includes other land types within it. We estimate the relative contribution of each land surface type to the suspended sediment load of the Wildcat Slough using a sediment fingerprinting technique. We use a statistically verified suite of tracers including trace metals and stable isotopes of carbon and nitrogen, which show significant variances between the different land types within the Wildcat's watershed. A mixing model will use the concentrations of these tracers from samples collected in suspension and from the different land types to estimate the amount of sediment each source contributes.

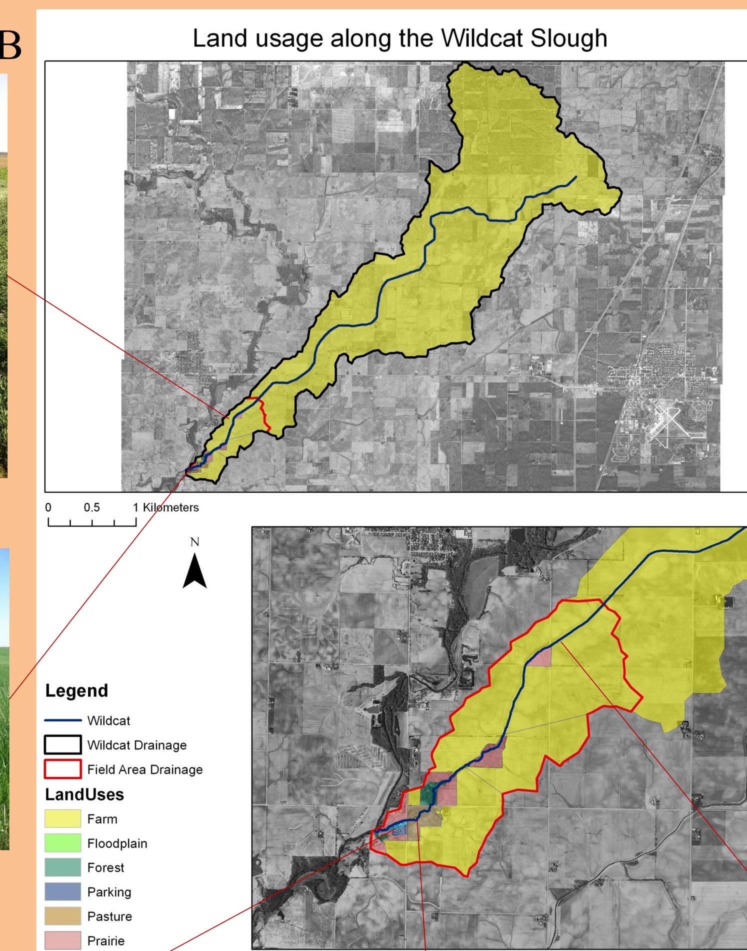
We evaluate the influence of landforms in controlling sediment sources within the Wildcat Slough basin. The Wildcat Slough undergoes morphological changes as it approaches the confluence with the Sangamon River. The upper reaches of the Wildcat Slough are retained within a deep, channelized ditch with a complex network of drainage tiles emptying into it as it flows through the farm fields. Closer to the confluence, however, it freely meanders through forest, pasture, and prairies and has established point bars and outer banks. The correspondence between land use and channel morphology allows us to track the contributions to suspended load as a function of channel character.

Field Area

A

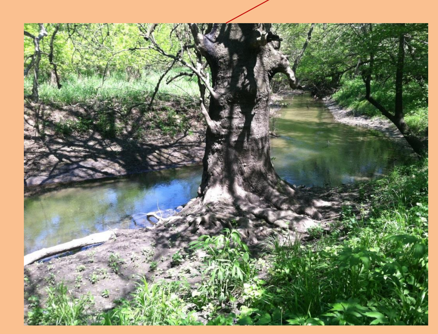


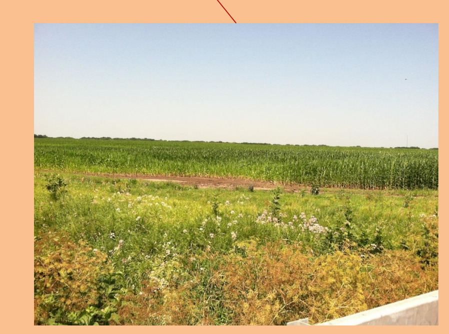
B



C

(C) Locations of land and suspended sediment samples.





A) The Wildcat Slough is located in central Illinois, about 20 miles north of Champaign in Fisher, Il. (B) Land in the Wildcat Slough watershed is used mostly for farm fields, but also includes pastures, prairies, forests, and a floodplain in the study area. About 2km from its confluence with the Sangamon River, the Wildcat changes from a channelized ditch to a meandering river.

Results

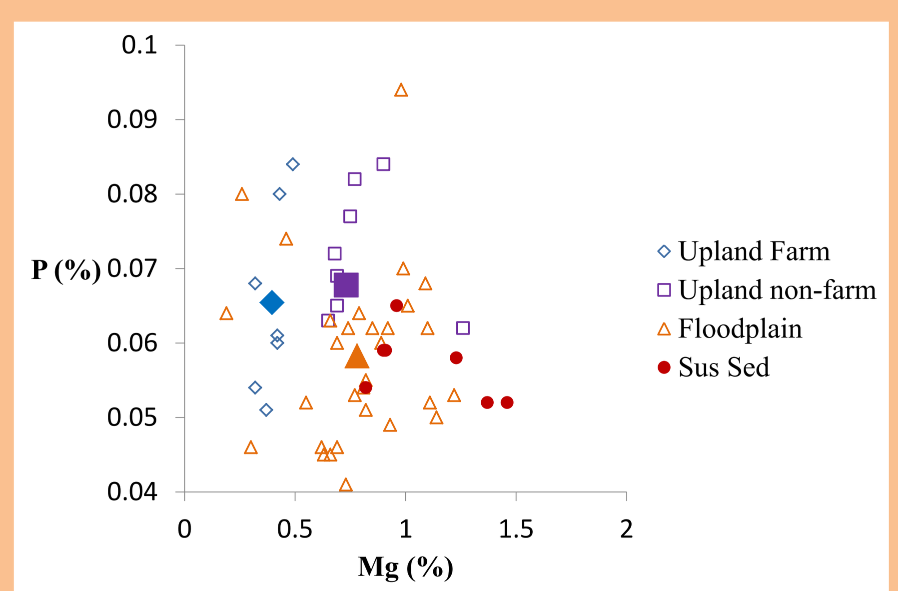
Analysis of variance between source tracers and creating the composite fingerprint

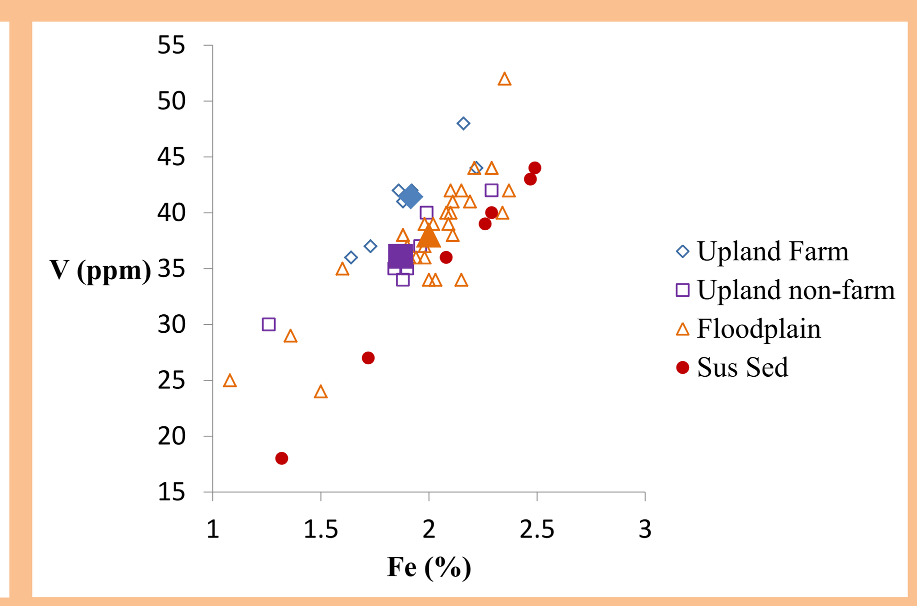
Tracer	*H* value
P	19.26
Mn	17.84
V	15.56
Mg	15.04
Ni	14.35
Sr	14.33
Fe	14.21
Ca	14.03
Sc	13.17
Y	13.01
Al	12.14

Tracer	*H* value
Cr	10.43
K	9.86
Na	8.69
Co	8.52
Zn	6.65
Ba	6.38
La	4.73
Ti	2.66
Cu	1.78
Pb	0.71

Each tracer was subject to an analysis of variance test to assess its ability to differentiate between each sediment source using the Kruskal-Wallis *H* test. All *H* values exceeding 11.07 indicate that the tracer's concentrations for each source are statistically different (p>0.95). By using all of the tracers that passed the *H* test as inputs in a discriminant function analysis, a composite fingerprint of P, Mn, and Mg was created. Together they successfully differentiate the sources with 100% certainty. The discriminant analysis was unable to explain 20.3% of the variations between the sources, as indicated by Wilks' Lambda.

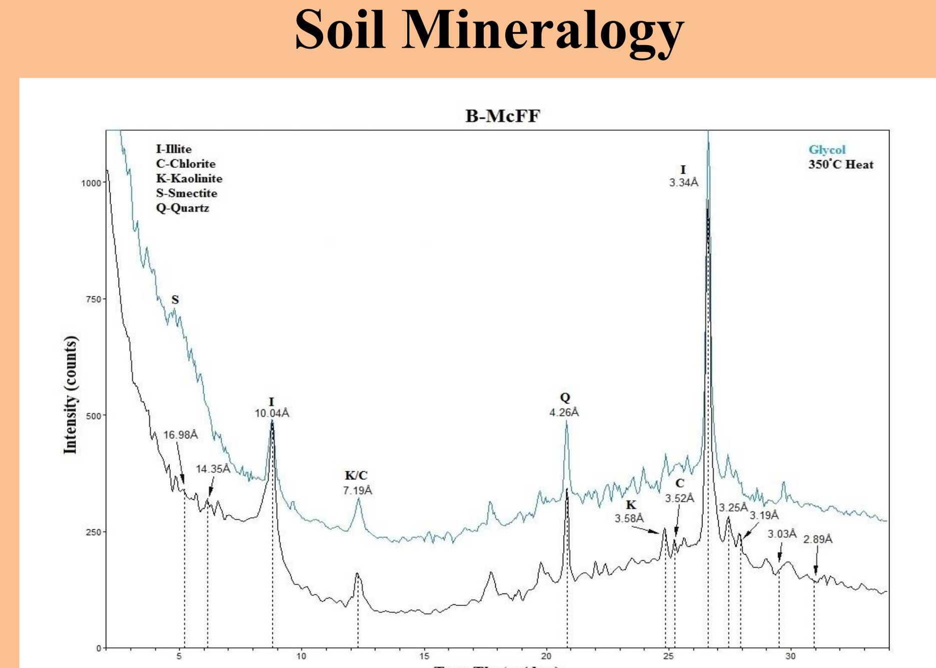
Tracers used in discriminant function	Cumulative % of function's ability to discriminate between sources	Wilks' Lambda	Sig.
P	69.6%	.604	.137
P and Mg	94%	.323	.002
P, Mg, and Mn	100%	.203	.000





Two example graphs, which pair tracers that pass the Kruskal-Wallis *H* test, shows slight zonation between the sources and where the suspended sediment fits in relation to these zones. It appears from these graphs that the suspended sediment derives mostly from floodplain sediments.

Soil Mineralogy



XRD analysis of this sample is representative of most soils in the Wildcat's watershed. The largest peaks indicate Illite. The change in curvature between the glycol and heat analyses from 0º-8º represent a decrease in D-spacing common among smectite after heating. The broad hump from 15º-30º represents a strong presence of organic material.

Future Work

- Analysis of stable carbon and nitrogen isotopes, as well as C/N ratio.
- Finalizing the composite fingerprint with the input of organic isotope concentrations.
- Determining relative contribution of suspended load from each source using:

$$z^T = \sum (x_k^T \times P_k)$$

$$\sum P_k = 1$$

Acknowledgements

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