Implementation of the Revised Universal Soil Loss Equation within a GIS Framework

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Introduction:

Phosphorus and sediment runoff are the primary cause of eutrophication in Cheney Lake, which is the main water source for Wichita, Kansas. Best management practices (BMPs) such as no-till farming practices and nutrient management can be implemented to reduce phosphorus runoff on high-risk agricultural fields. The Revised Universal Soil Loss Equation (RUSLE) is a widely-used method for estimating soil erosion, which is a major factor in phosphorus transport from fields and can serve as a general indicator of non-point source pollution risk. While RUSLE is generally applied to individual fields, it is also possible to create a GIS model based on the RUSLE calculation. This model benefits from flexibility in data sources, high spatial resolution, and intuitive operation. The resulting erosion estimates can be used to prioritize or evaluate BMP placement.

Objectives:

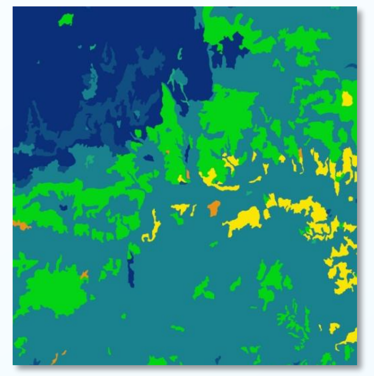
The goal of this project was to develop and validate a Geographic Information System (GIS) model based on the Revised Universal Soil Loss Equation (RUSLE) to estimate watershed-scale erosion, prioritize agricultural land for BMP placement, and evaluate existing placement of BMPs within the Cheney Lake watershed.

Methods:

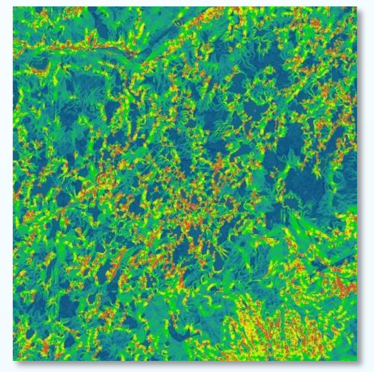
The version of RUSLE used as a basis for this GIS method is a simple multiplicative model.

$$R \times K \times LS \times C \times P = A$$

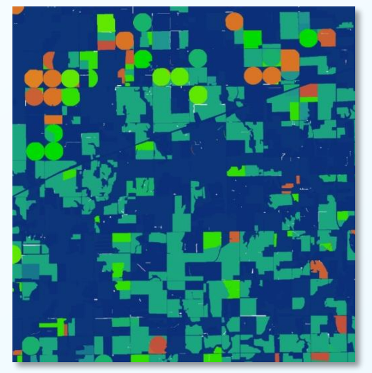
Monthly rainfall intensity data was provided by USDA-NRCS and interpolated over the watershed.



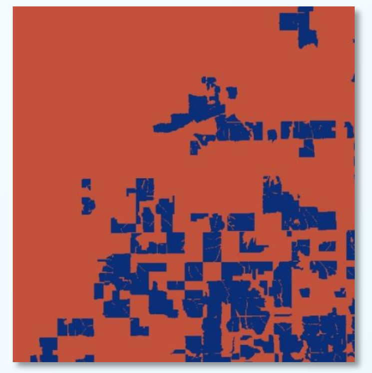
The soil erodibility factor is available as part of the Soil Survey Geographic (SSURGO) dataset.



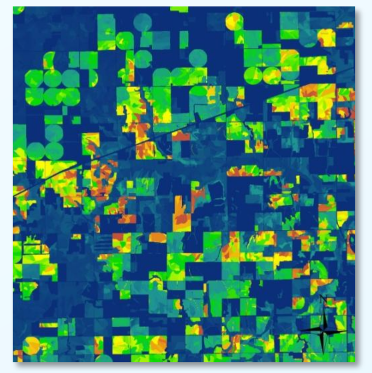
Elevation data from the National Elevation Dataset was processed by an ArcGIS script* created to calculate the LS factor



Spatial data used to estimate the surface cover and land use was provided by the National Agricultural Statistics Service's Crop Data Layer



The locations of conservation practices within the watershed were provided by Cheney Lake Watershed Inc.



Multiplying the factor layers produces an annual erosion estimate.

*Van Remortel, R., M. Hamilton, and R. Hickey, 2001. *Cartography*. V. 30, no. 1, pp. 27 - 35.

Model Validation

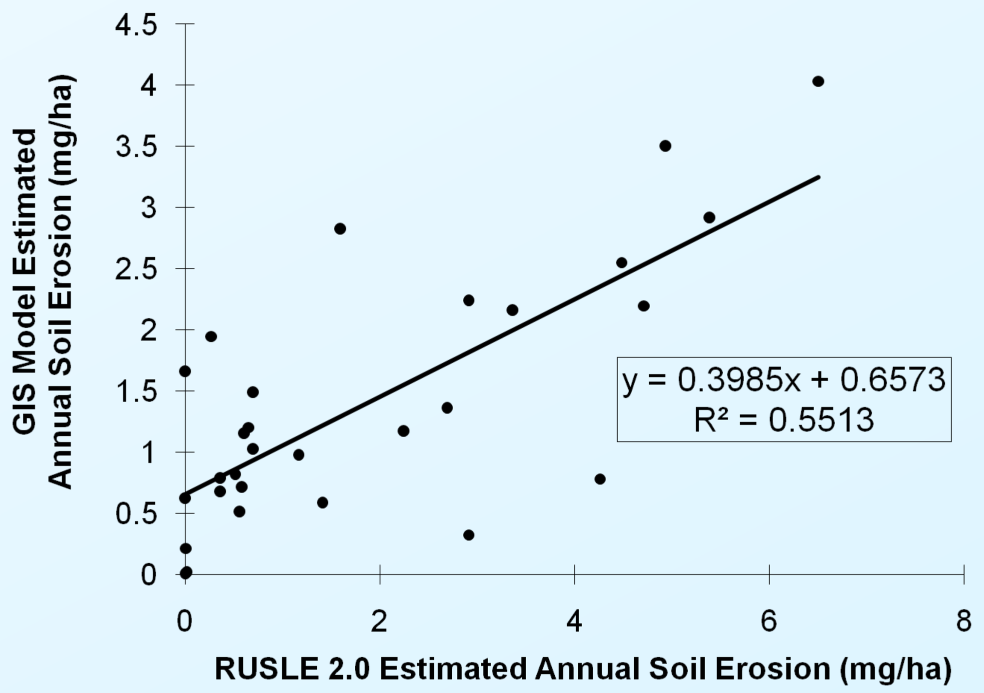
The GIS model was compared to non-GIS soil erosion estimates for individual fields.

25 locations were selected from the Red Rock Creek and Goose Creek sub-watersheds.

Annual soil erosion was estimated using the RUSLE 2.0 windows interface with using input collected via direct field measurements and information provided by producers.

The Nash Sutcliffe model efficiency coefficient was 0.44

Despite the low correlation score, the model functioned adequately for identifying high-eroding fields.



Results and Discussion

The RUSLE-based GIS method was used to estimate soil erosion for the Cheney Lake watershed. Fields with an average erosion within the top 20% of the watershed were prioritized as high-eroding. These fields account for an estimated 56% of the total watershed erosion, which is a major source of phosphorus runoff into the lake. No single RUSLE factor dominated the model in identifying high-eroding fields. Further analysis was done to describe the high-eroding areas in relationship to landuse, management, and BMP placement.

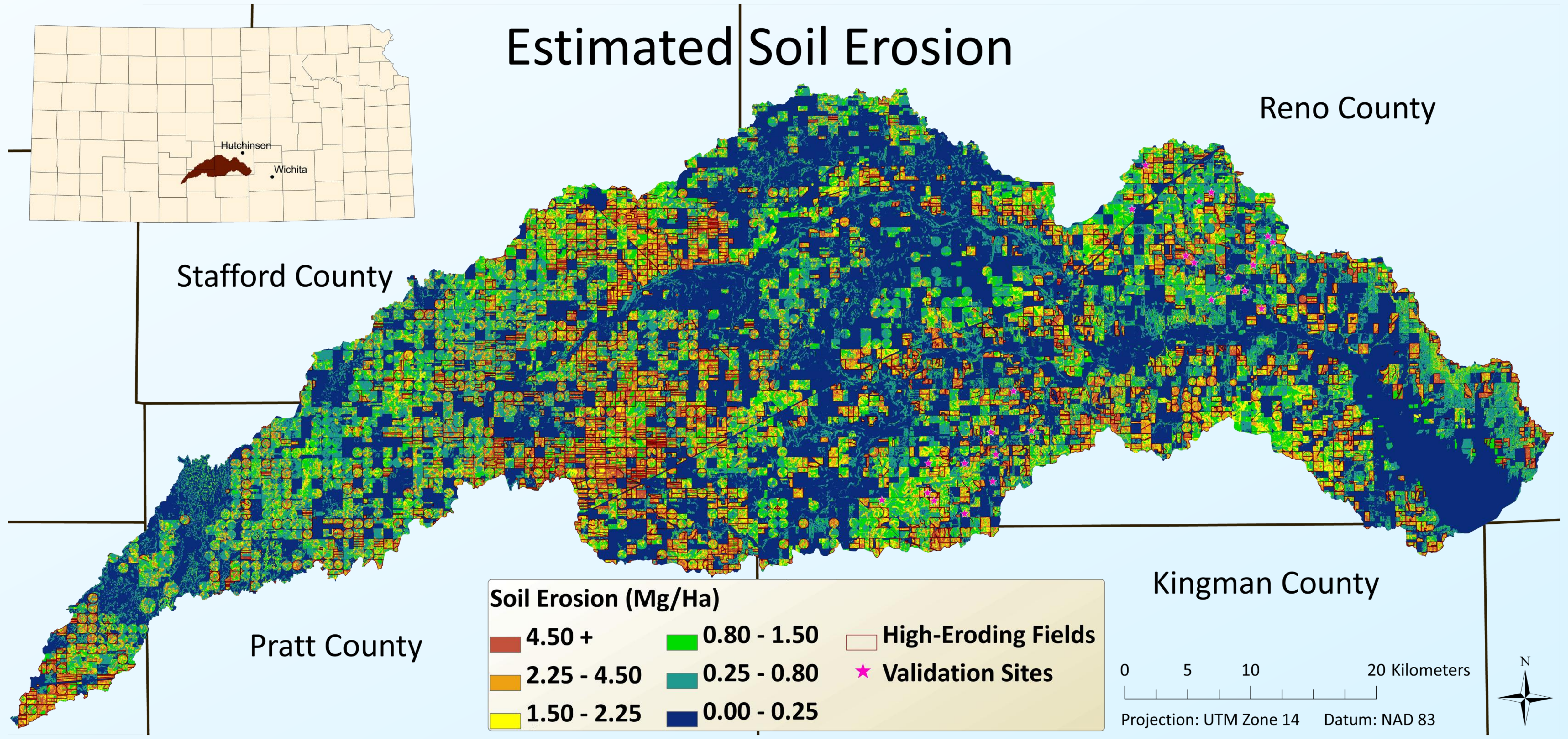


Table 1. Relationship between BMPs and high-erosion fields.

	High-eroding land affected by change	Low-eroding land affected by change
Financially-Incentivized BMP implemented	12.73%	11.04%
Enlisted in the Conservation Reserve Program (CRP)	13.59%	5.12%
Voluntary No-till implementation	13.47%	17.87%

Conditions from 1994 were used to estimate erosion across the watershed and identify high-eroding fields. These areas were compared with various BMP implementation which has taken place since that time. The results of this analysis are seen in Table 1.

High-eroding areas were analyzed with respect to the landcover present at that location. Table 2 shows the amount of each landcover in the watershed and the probability that it will be considered high-eroding.

Table 2. Crop rotation and landcover comparison.

Landcover / Crop Rotation	Percent of Watershed	Area Identified as High-Eroding
Wheat-Sorghum-Soybean	1.07%	62.32%
Corn-Soybean	5.25%	51.97%
Wheat-Sorghum	6.90%	64.47%
Wheat-soybean	2.57%	14.72%
Continuous Corn	6.94%	17.17%
Continuous Sorghum	1.24%	61.02%
Continuous Wheat	24.75%	43.53%
Continuous Alfalfa	1.63%	3.57%
Pasture/Range	26.78%	0.27%
Non-agricultural landuse	22.88%	0.00%

A subset of the watershed was surveyed for current tillage practices. Table 3 shows the relationship between areas identified as high-eroding and the tillage practice at use in that location.

Table 3. Tillage comparison.

Tillage Type	Percent of Sampled Area	Area Identified as High-Eroding
Conventional Tillage	49.43%	32.15%
Reduced Tillage	18.51%	32.68%
No Tillage	13.62%	4.30%
Pasture	18.44%	3.87%

Conclusions

•The RUSLE-based GIS method was shown to adequately identify high-eroding fields, and provide realistic field-scale erosion estimates across the watershed.

•High-eroding land in the watershed has been substantially more likely to have CRP management implemented, but is not more likely to have received incentivized BMPs or transitioned to no-till.

•The field-scale erosion estimates for this watershed will help prioritize future soil BMP placement and soil conservation efforts.