Impacts of Land Management Changes on Streamflow in the Northern Wabash River Basin

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Introduction

- To accurately predict past (and future) streamflow dynamics, it is necessary to quantify how soil characteristics vary across the landscape.
- The current U.S. Soil Survey is presented as discrete polygons called map units, within which soil physical properties are represented by single values that do not truly represent soil variability in a landscape.

Objectives

- This study will address the following objectives:
  1. Create spatially continuous property maps that can be used to quantify hydrologic characteristics.
  2. Validate the predictive maps by comparing property values to available soil characterization data.

Materials and Methods

Study Area

- The Big Lick Creek watershed lies in Blackford, Delaware, and Jay counties in east-central Indiana (Figure 1).
- Two 14 digit hydrologic units drain a heavily agricultural area of approximately 85 km^2, eventually joining the Mississinewa and finally the Wabash River.

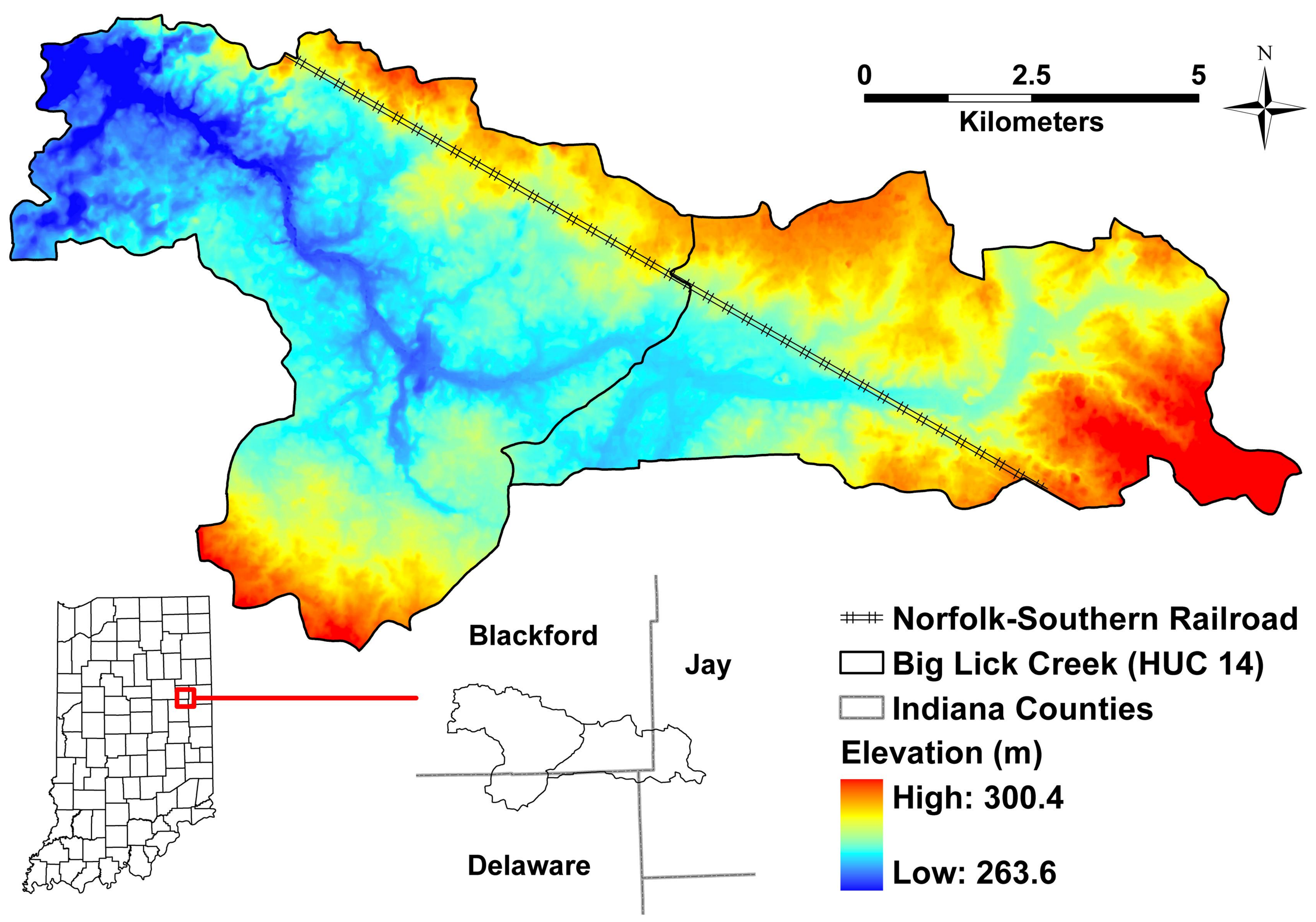

Figure 1. Big Lick Creek study area and elevation

Terrain Attribute Soil Mapping (TASM)

- Elevation derived terrain attributes (Figure 2) were created using the System for Automated Geoscientific Analyses (SAGA) software, version 2.0.0.

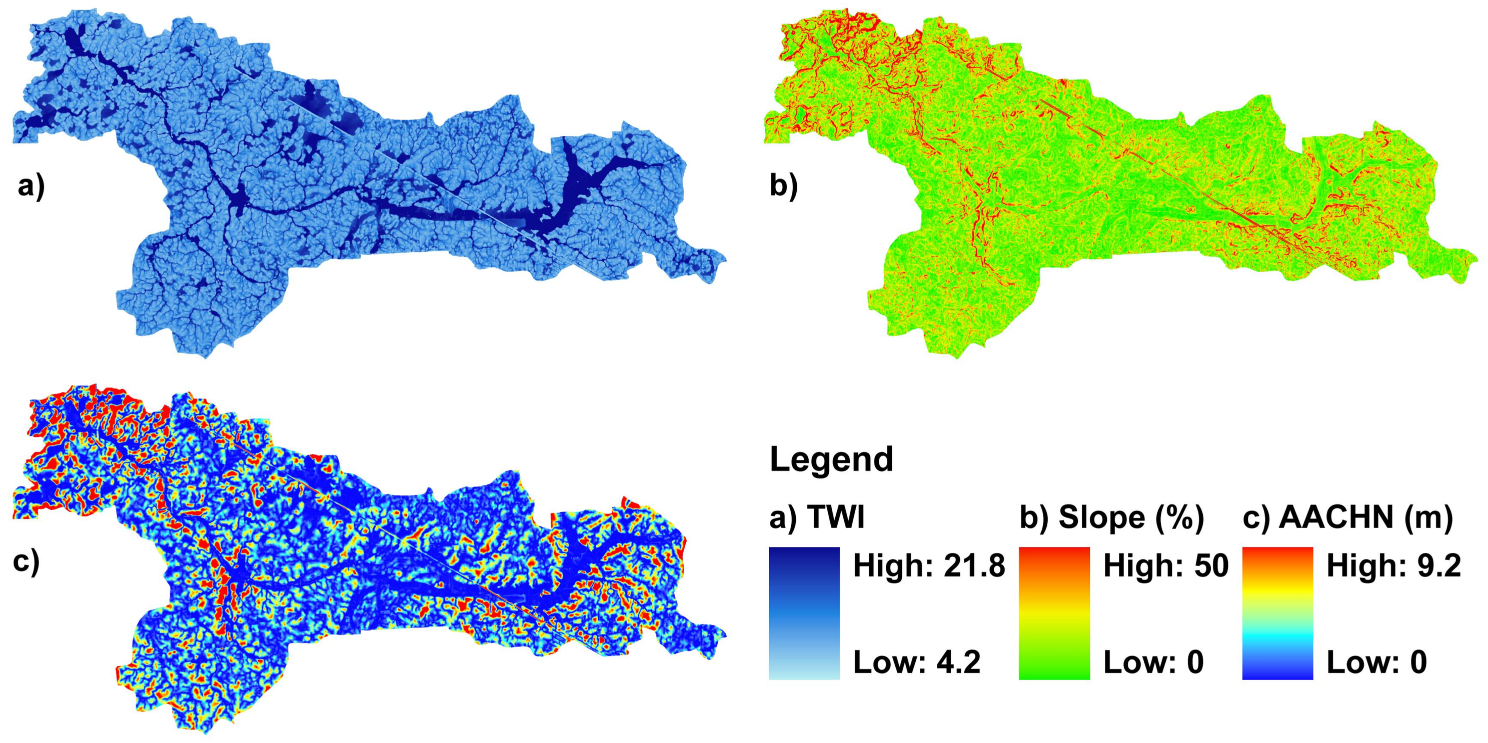

Figure 2. Terrain attributes of Big Lick Creek. a) Topographic Wetness Index (TWI); b) Slope; c) Altitude above Channel Network (AACHN)

- The 1:24,000 Soil Survey Geographic (SSURGO) Database defines 28 map units within the watershed (Figure 3), of which the Blount, Bono, Glynwood, Pewamo, and Saranac series account for 94% of the area.
- The Soil-Landscape Inference Engine (ArcSIE) extension to ArcGIS was used to quantitatively relate soil classes to landscape positions (Figure 4).

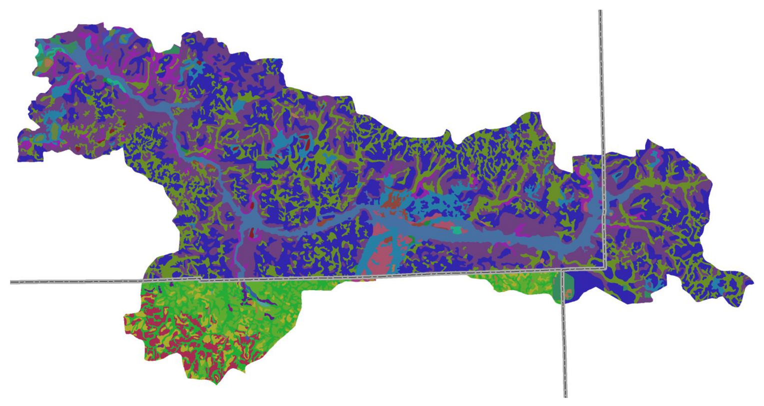

Figure 3. SSURGO map units (Note county boundary)

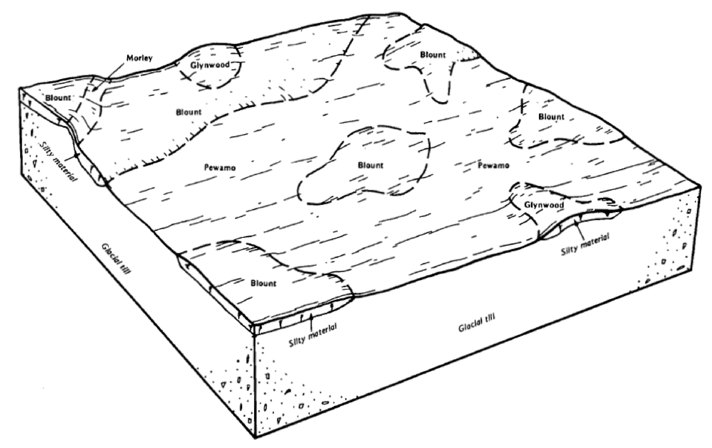

Figure 4. Block diagram depicting the soil-landscape relationship

- Using fuzzy logic, a "hardened" soil class map was made based on distributions of the terrain attributes (Figure 5).

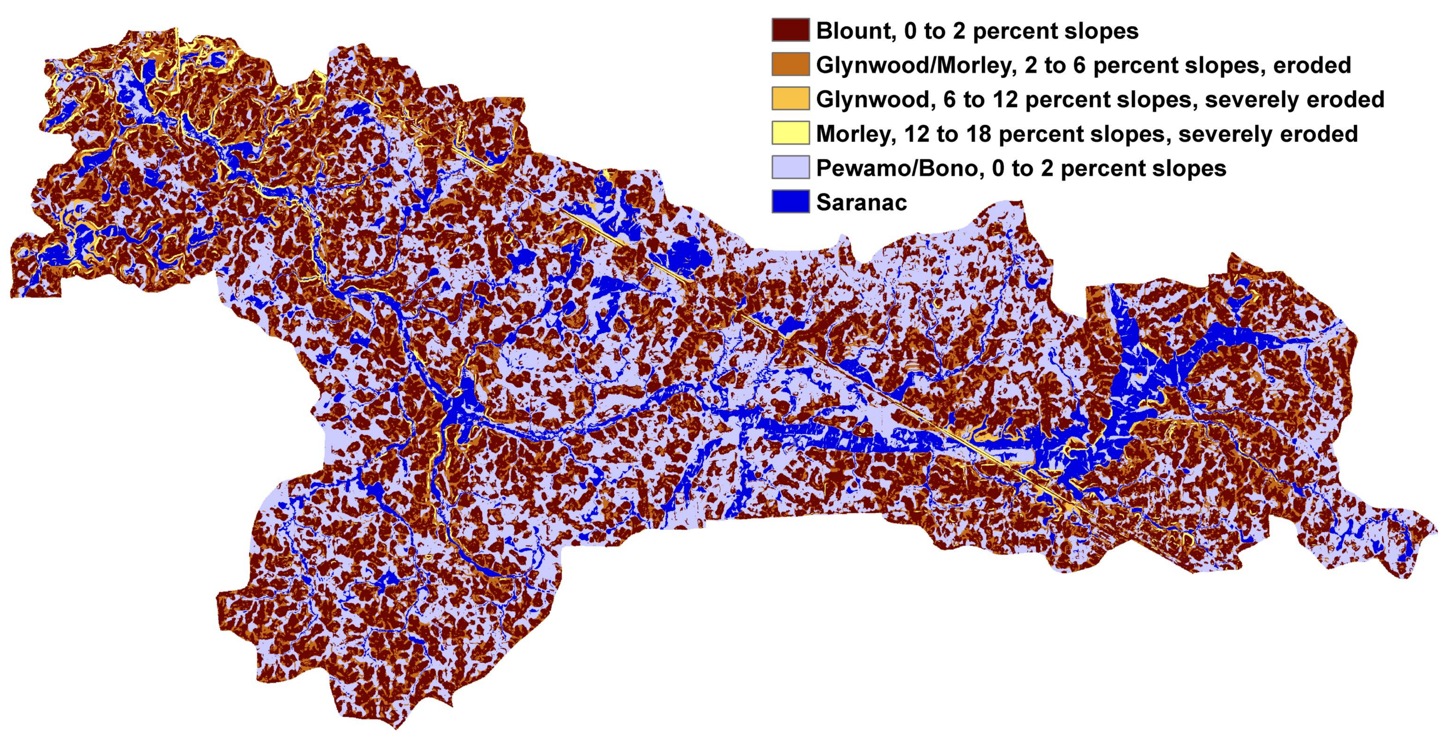

Figure 5. Soil class map for Big Lick Creek

Creating Continuous Soil Property Maps

- Property maps (Figure 6) were generated using data mined from the county soil surveys and the fuzzy membership values of the soil classes (Equation 1).

$$H_{ij} = \frac{\sum_{k=1}^{l} s_{ij,k} h_k}{\sum_{k=1}^{l} s_{ij,k}}$$

where,
H_{ij} = the property value at location (*i,j*)
$s_{ij,k}$ = the fuzzy membership value at (*i,j*) for soil class *k*
l = the total number of soil classes
h_k = the typical property value of soil class *k*

Equation 1. Equation for estimating soil properties using fuzzy logic

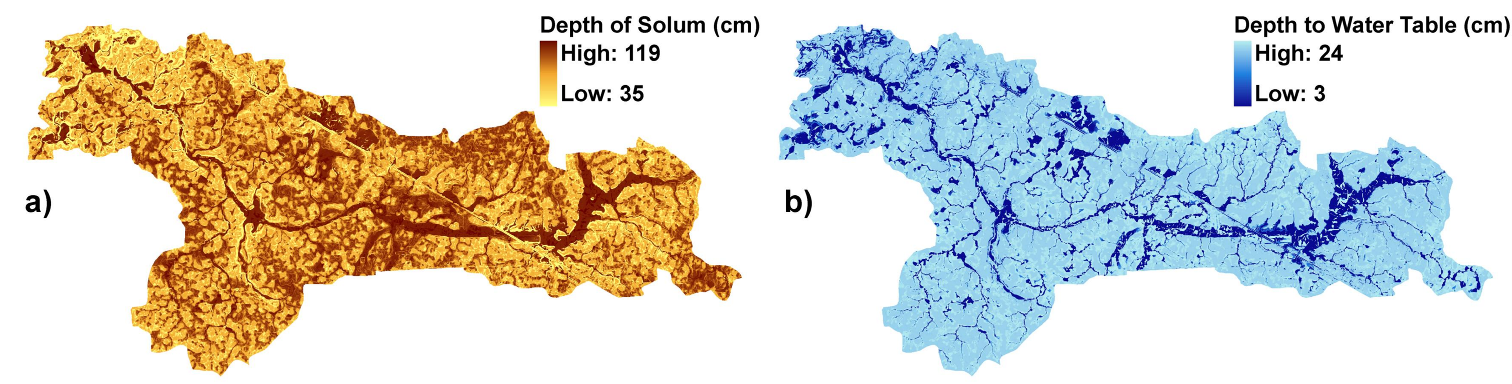

Figure 6. Continuous property maps of a) Depth of Solum and b) Depth to Water Table

Results and Discussion

- The National Cooperative Soil Characterization Database (NCSC) contains analytical data for more than 20,000 georeferenced pedons in the United States.
- Two pedons with characterization data are found in the watershed. Observed NCSC property values were compared to the predicted TASM values (Table 1).

Table 1. Observed (NCSC) and predicted (TASM) soil property values

Pedon	Depth of Solum (cm)		Depth to Water Table (cm)	
	NCSC	TASM	NCSC	TASM
1980-IN009-008	122	116	33	23
1980-IN009-009	124	93	0*	20

* Chroma 2 described in surface horizon

- More validation points are needed to determine if the predicted property values are statistically different from the observed values, but qualitatively, the TASM maps well represent the soil-landscape relationship.

Conclusions

- Continuous, predictive soil physical property maps can be created using the soil-landscape inference model.
- The quality of the map is ultimately dependent on the tacit knowledge of the soil scientist, but errors or unwanted features in the elevation model also affect it.
- In the future, the method described here will be scaled up to the Wabash River basin, and predictive maps will be used to quantify historic changes in wetlands and hydrologic response.

References

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