Quantifying Soil Landscape Relationships in the Shawnee Loess Hills: A University and Soil Survey Collaborative Project

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Cooperators Contributions

- Funded by: NCSS, Kentucky, Indiana, Purdue University
- NCSSL – Full Characterization with trace elements, EM surveys and Amoozemeters
- This year… graduate student from SIU, University of Kentucky,
- USDA-ARS scientists and other University scientists are discussing using these sites in other research projects

Training

- Soil scientists, graduate students and student trainees received training in soil descriptions and sampling
- Training in hydrologic measurements
- Training in EM and GPR surveys

Objectives of the Regional Project

1. Develop a model of soil distribution on selected benchmark landscapes;
2. Assess major factors controlling soil development and spatial variability;
3. Determine variables that serve as markers of soil type, pedogenesis and water movement such as clay distribution, soil color/redox features, or geochemistry;
4. Use information from these studies for mapping loess soils.

Methods

- Indiana – paired forest and pasture watersheds (0.5-2 m loess over residuum);
- Illinois – paired forest and pasture watersheds (3-5 m loess);
- Kentucky – paired forest and pasture watersheds (2-4 m loess).

Methods

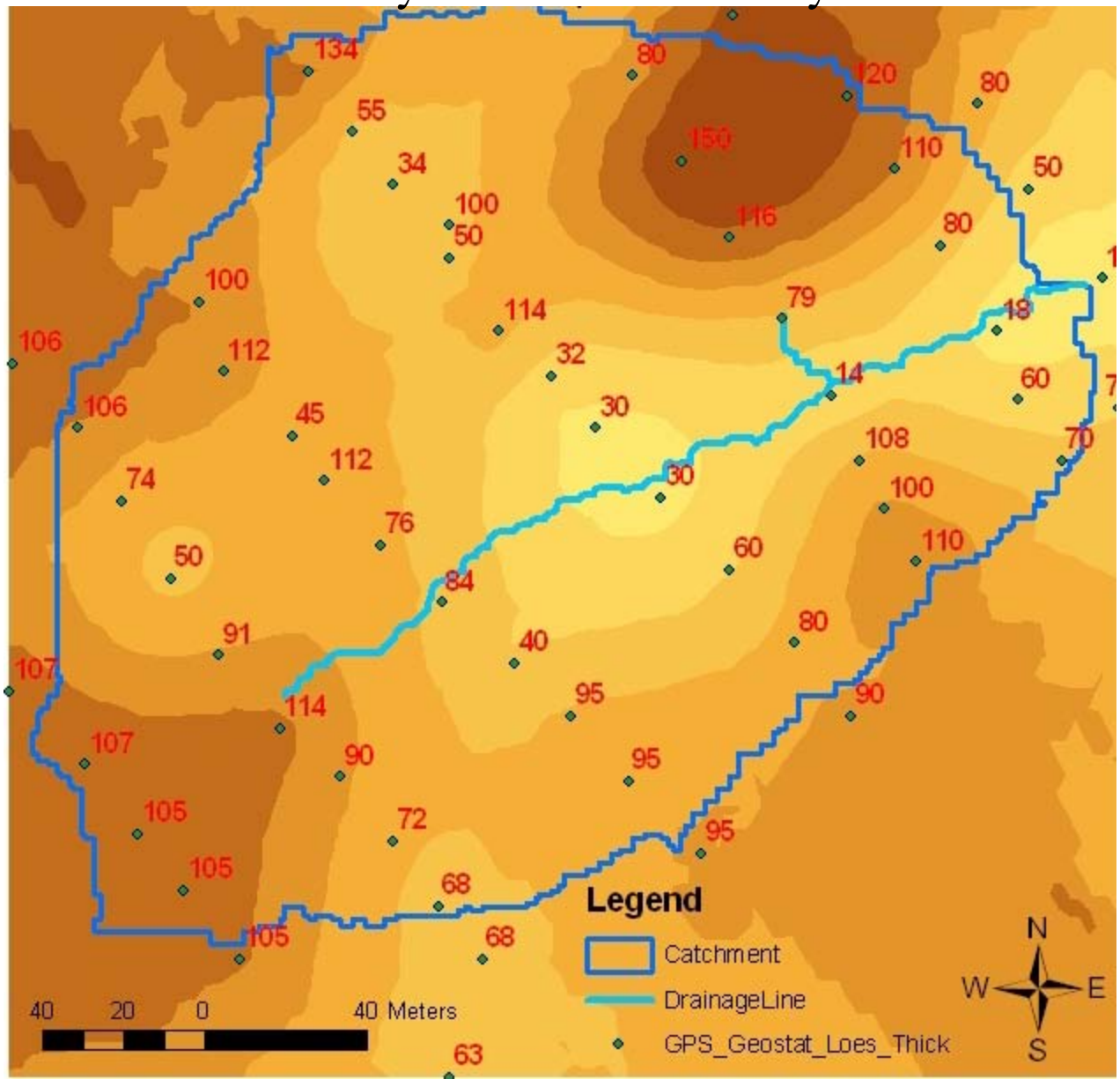
- Soil Information:
  - Transects with full chemical and physical characterization including trace elements;
  - First order surveys including carbon and bulk density.
- Soil Water Movement:
  - Constant head permeameter (Amoozemeter);
  - Piezometers/wells with pressure transducers;
  - Flumes within each watershed;
  - Rain gauges;
  - Soil Moisture sensors.
- EM surveys;
- Digital soil mapping and hydrologic modeling.

Focus Areas

- Spatial variability of soil properties
- Fragipan distribution
- Carbon distribution related to landforms and landuse
- Hydraulic conductivity
- Geochemistry and distribution of trace elements

Detailed Soil Survey – Preliminary Results

Loess Thickness



Franzmeier's Fragipan Model

- Forested landscape
- Slopes <15%
- 0.75-2 m of loess over a hydraulically limiting layer
- Acid soils (pH less than 5.5)
- Moisture deficits

Hydraulic Conductivity at the Pasture Site

Water table monitoring

- Piezometers and Wells:
  - piezometers at two depths and three landscape positions;
  - wells at three landscape positions.
  - hourly readings with pressure transducers and dataloggers
- Flumes
  - 2 flumes (pasture and forested small catchments).
  - hourly readings with pressure transducers and dataloggers
- Moisture sensors
  - sensors at two depths.
  - hourly readings with pressure transducers and dataloggers
- Rain gauges
  - 2 rain gauges installed at pasture and forested watersheds.
  - Continuous readings

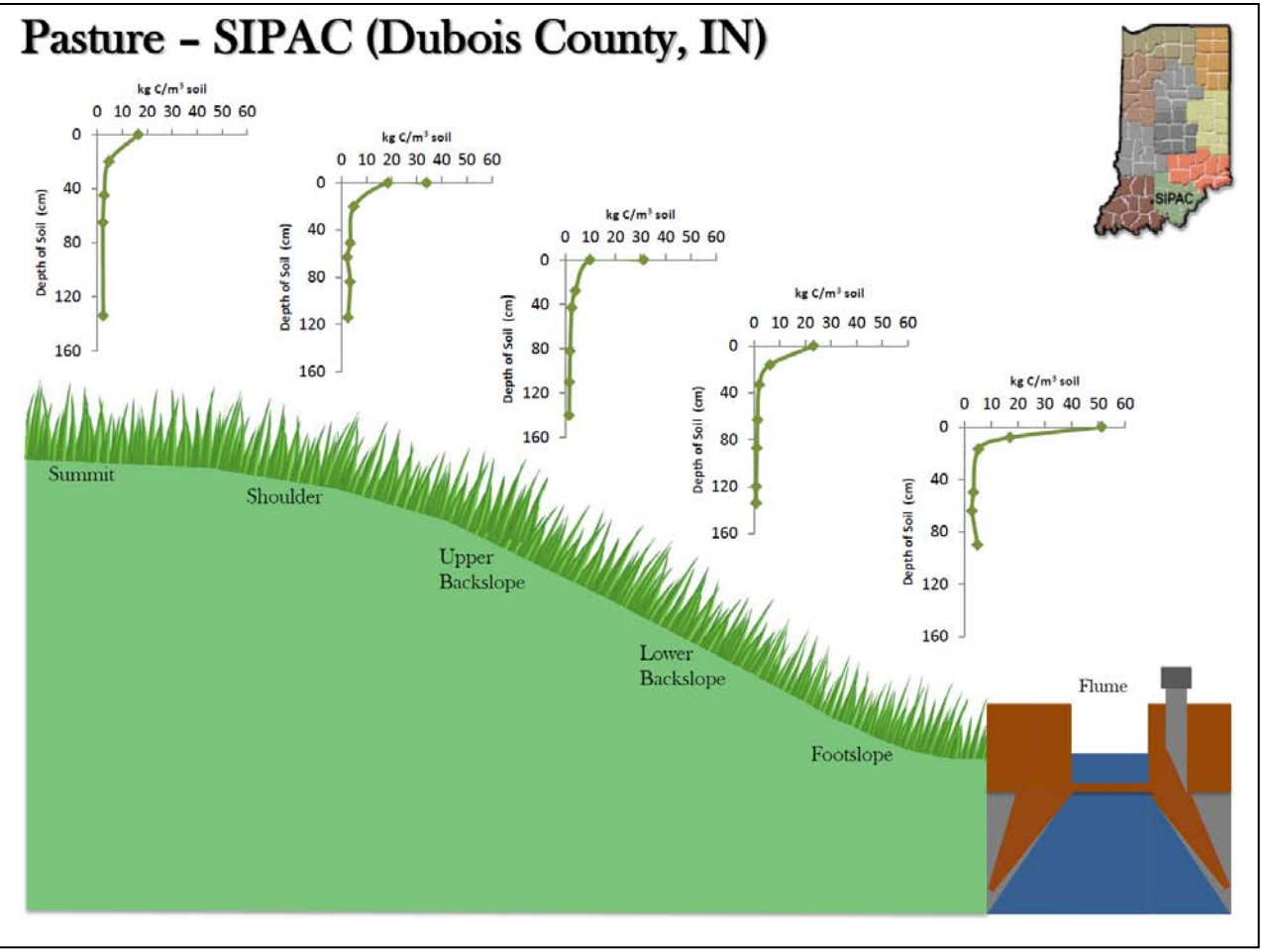
Ksat estimated in 3 ways

- Amoozemeter (constant head permeameter)
- Piezometers and wells (method developed by Kirkam, (1945) and Van Bavel and Kirkham (1948))
- Hydrographs from flumes
- Approximately 40 events. Determined using Darcy's law Q= -K*i*A
- where Q is discharge (L^3/T); K is hydraulic conductivity (L/T); i is the hydraulic gradient; and A is the area (L^2). The discharge on volume basis when divided by area gives the specific discharge or Darcy's velocity (L/T). The Darcy's law can then be written as:
- Q/A = -K*i
- Hydraulic gradient (i) is held constant then Q/A = -K. In order to satisfy this condition only instantaneous peak discharge values (Qpk) were selected from the flume data. Assumption was made that the soil column throughout the watershed was fully saturated.
- The hydraulic gradient was represented by the difference in elevation between the flume and the highest elevation of the catchment and assumed constant. The watershed size was used to represent the area A.

Conductivity Estimates

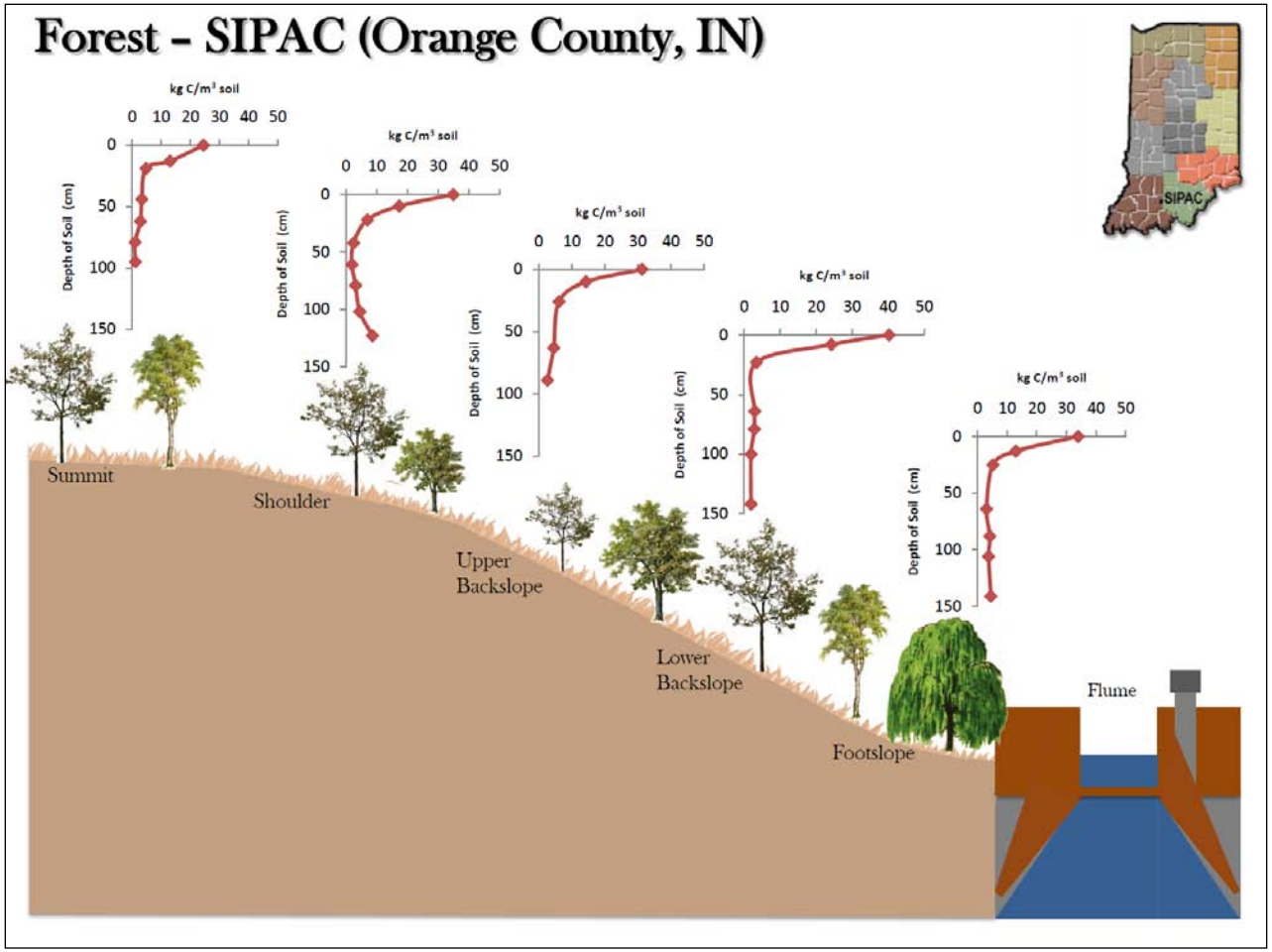
Method	Soil Horizon	Mean Soil Depth	Ksat (cm sec^{-1})
Amoozemeter	Ap/E/AB/BE	18	6.51E-06
	Bt1	42	7.27E-07
	Bt3	87	6.66E-08
	2Bt	89	1.44E-07
	Btx/2Btx	86	3.80E-07
	3Bt	100	2.91E-08
	Cr	126	7.38E-08
Wells	Ap/Bt1	49	3.54E-06
	Ap/Bt1	64	3.09E-06
	Ap -- Bt3	90	4.42E-06
Piezometers	Bt1	41	2.53997E-07
	Bt3/2Bt	62	5.78279E-07
	3Bt	105	3.5175E-08
Flume	Catchment		1.65E-06

Carbon Estimates



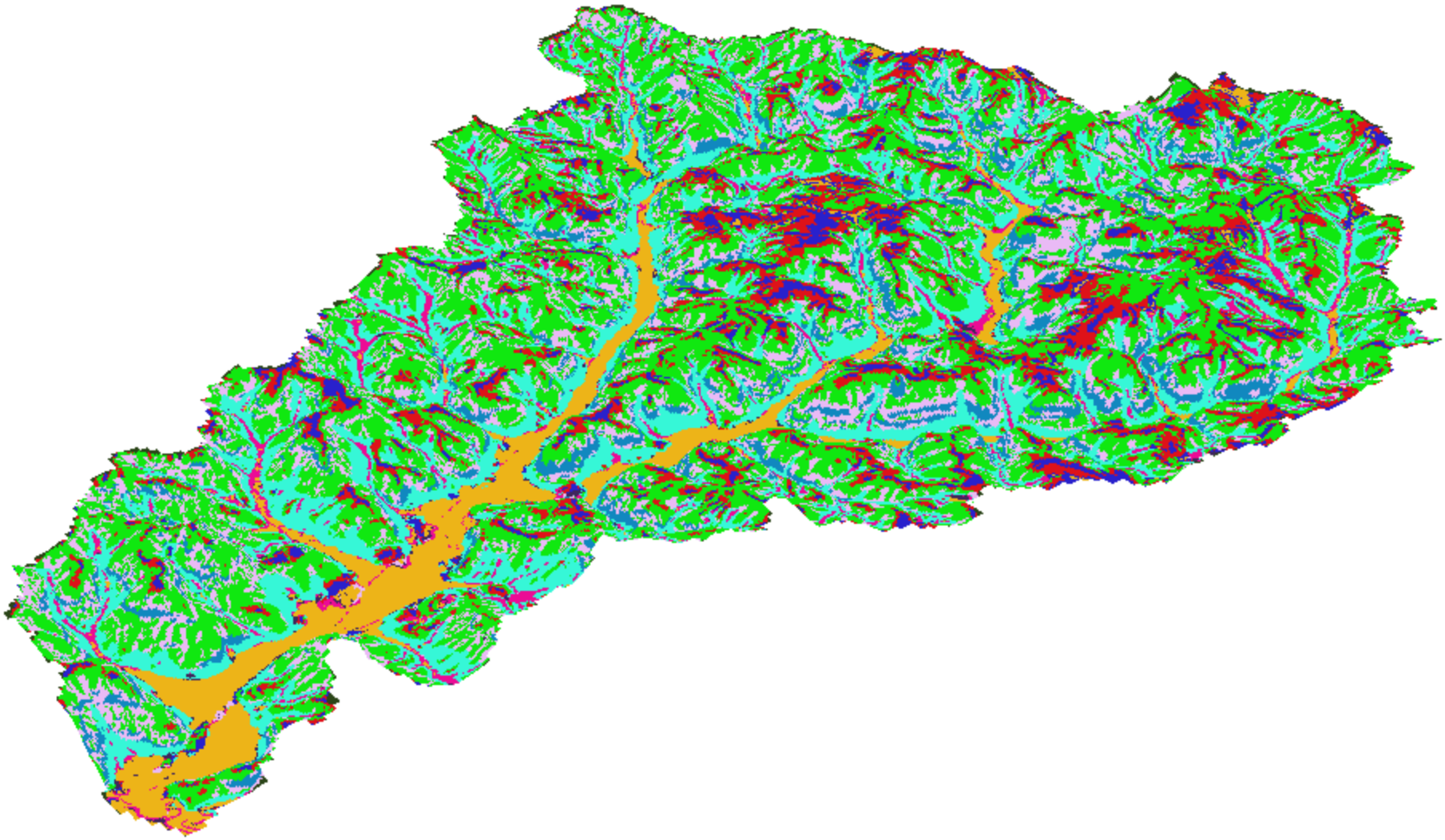
Pasture	Kg C/m³ soil
Summit	28.7
Shoulder	69.4
Upper Backslope	53.3
Lower Backslope	36.0
Footslope	85.1
Total C in Pasture	**272.5**

Carbon Estimates

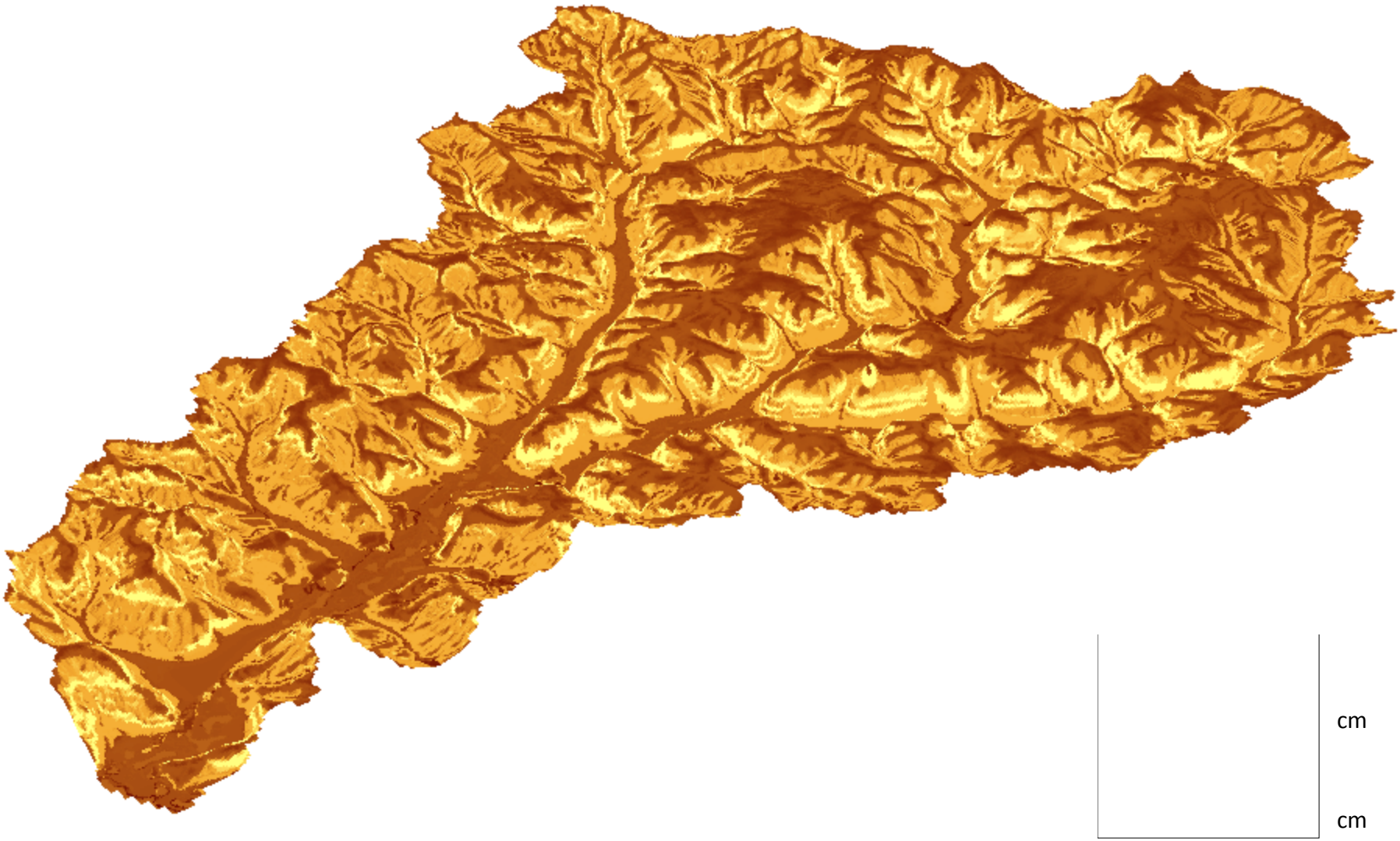


Forest	Kg C/m^3 soil
Summit	50.8
Shoulder	79.7
Upper Backslope	58.8
Lower Backslope	77.5
Footslope	67.5
Total C in Forest	334.3

Hardened Digital Map



Depth to Limiting Layer



Summary

- Project initiated by a Soil Survey Field Scientist (Sam Indorante)
- Mostly funded by NCSS, Kentucky Soil Survey and Indiana Soil Survey
- Provides a platform for grant submission and collaboration (University)
- Provides a place to test new technology, training and improving interpretations.