Regional Study of Loess Mantled Landscapes

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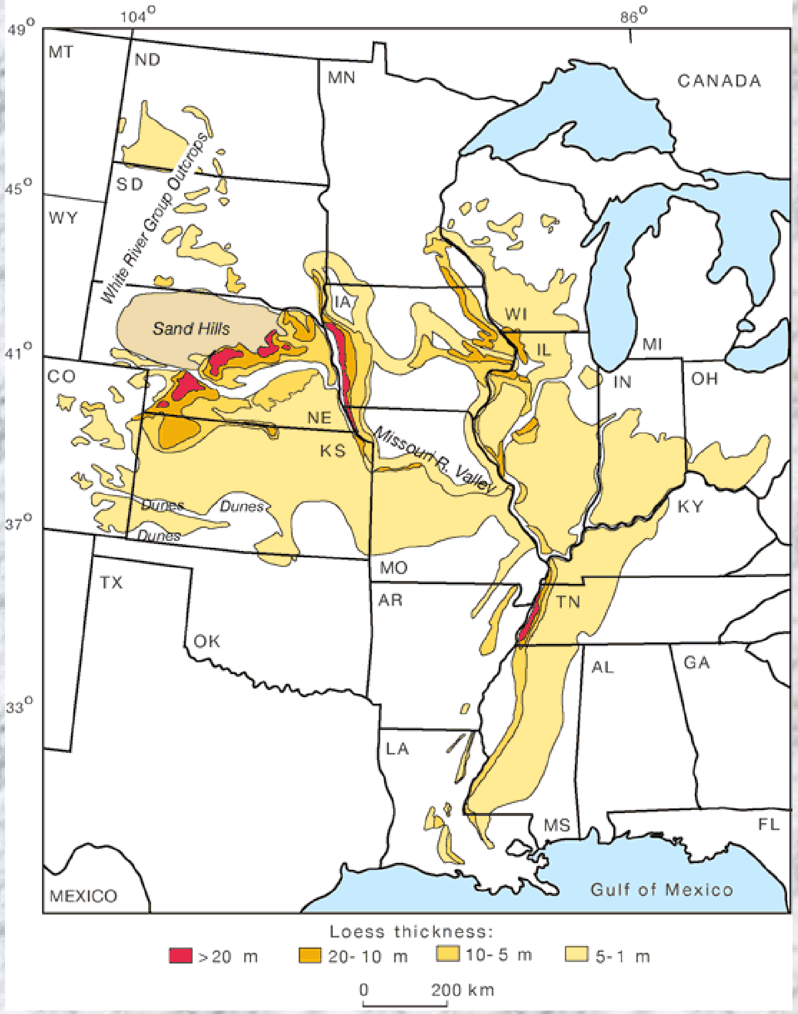
People Involved

- Indiana – Travis Neely and Soil Survey Staff;
- Illinois – Bob McLeese, Sam Indorante and Soil Survey Staff;
- Kentucky – Bill Craddock, Brad Lee and Soil Survey Staff;
- NCSS Lab Lincoln – Larry West, Mike Wilson, Phil Schoeneberger.

Loess Landscapes

- Loess sediments and their associated soils cover around 10% of the earth (Rhoton and Markewich, 2006);
- Much of the Midwest is covered with loess.



Soils and landscapes

- Comprise three-dimensional systems that co-evolve through chemical-physical weathering, erosion and deposition;
- Must comprehend and quantify relationships to map;
- Within a common geomorphic surface, *water*, driven by topography provides the energy for differentiation.

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 – (Planned) paired forest and pasture watersheds (2-4 m loess).

Methods

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

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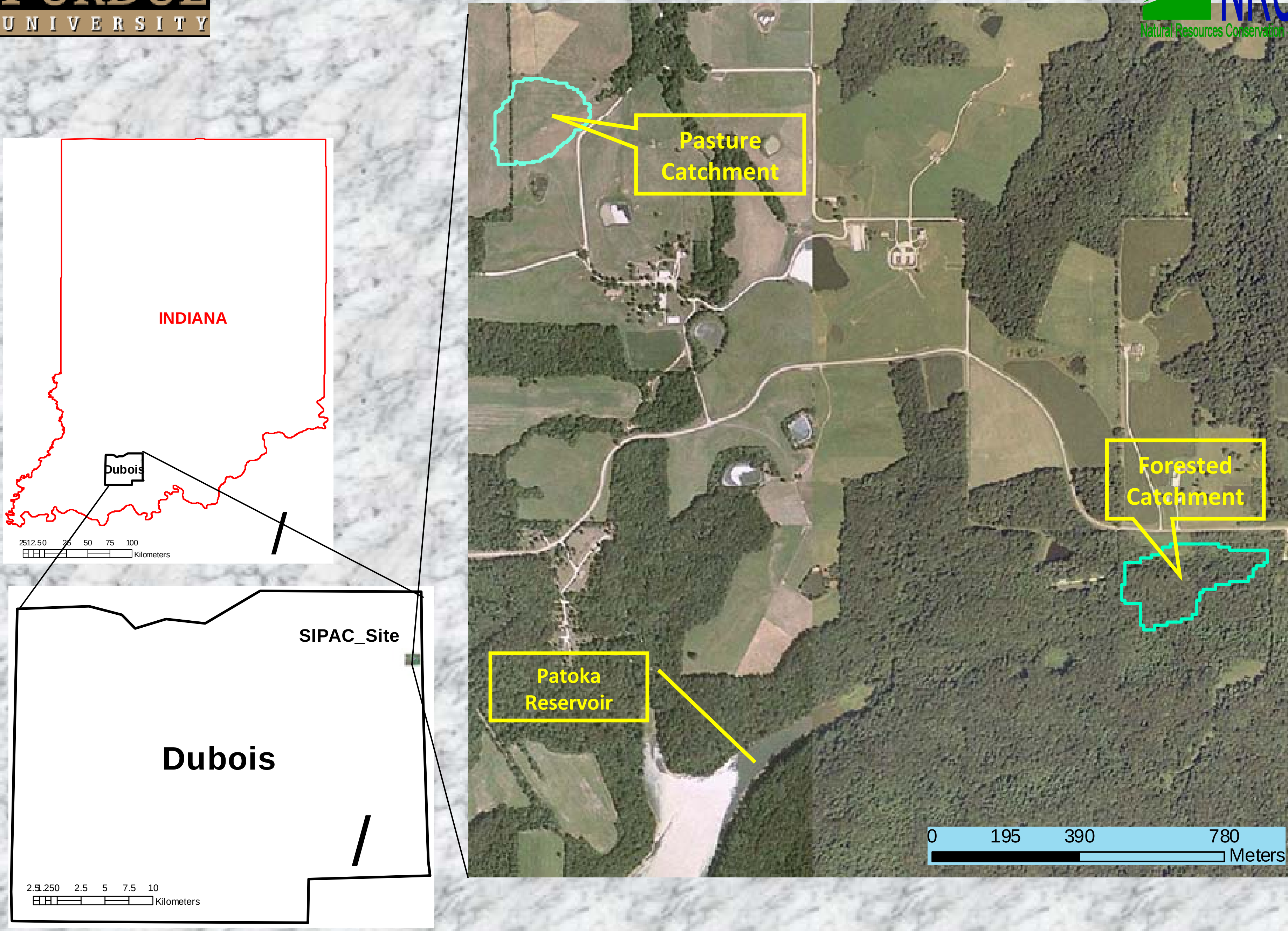

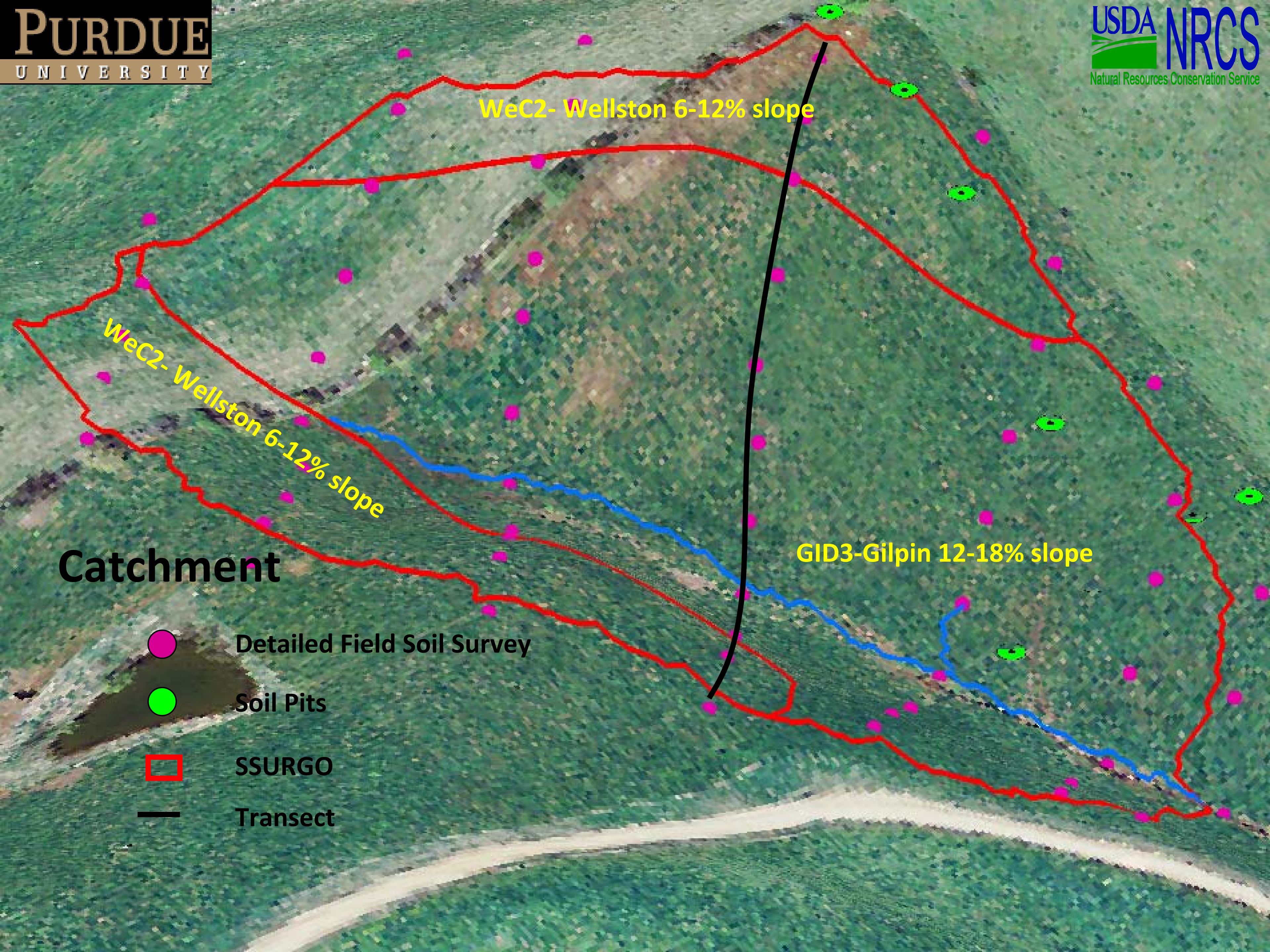
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WeC2- Wellston 6-12% slope
WeC2- Wellston 6-12% slope
GID3-Gilpin 12-18% slope
Catchment
Detailed Field Soil Survey
Soil Pits
SSURGO
Transect

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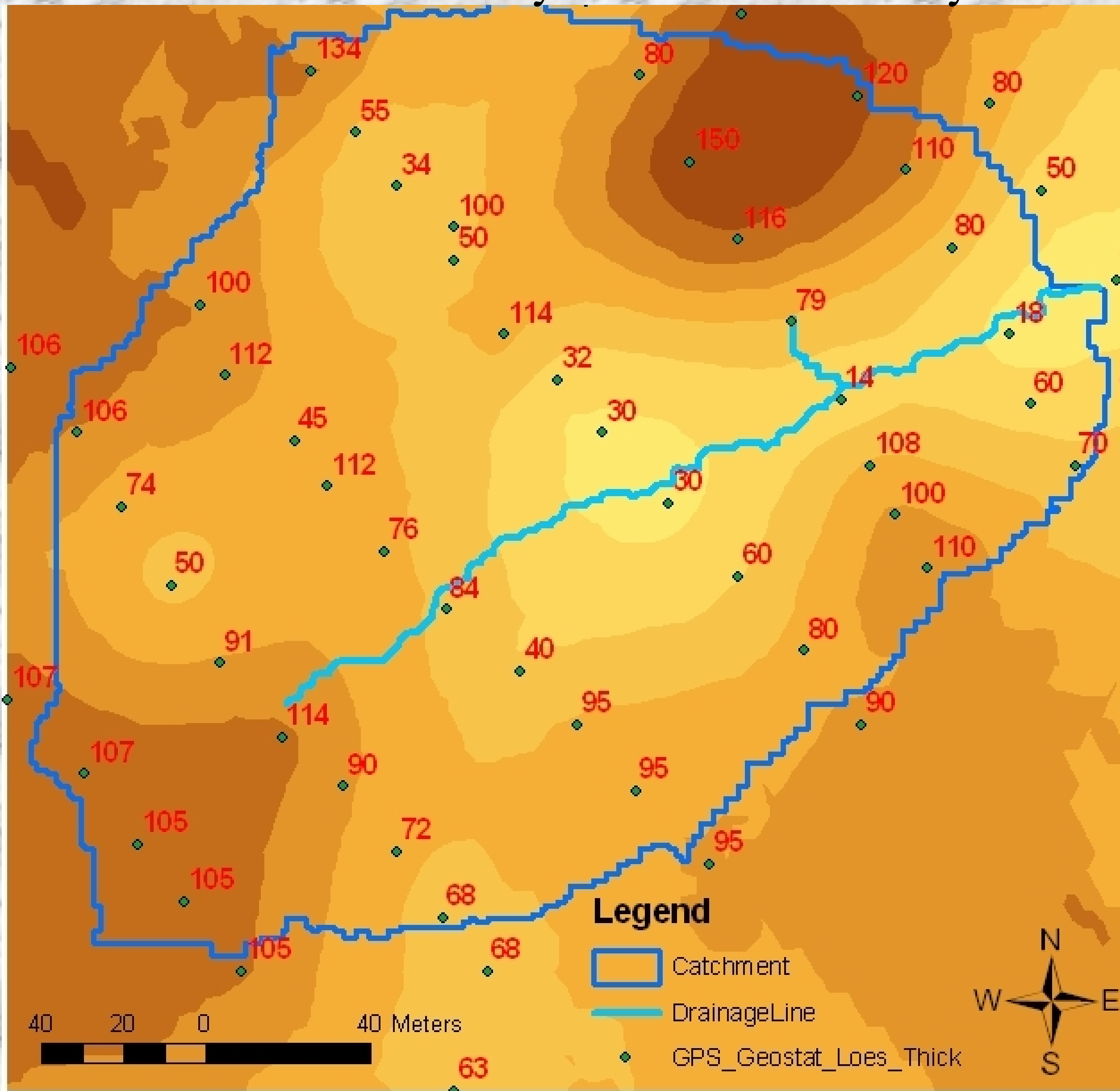
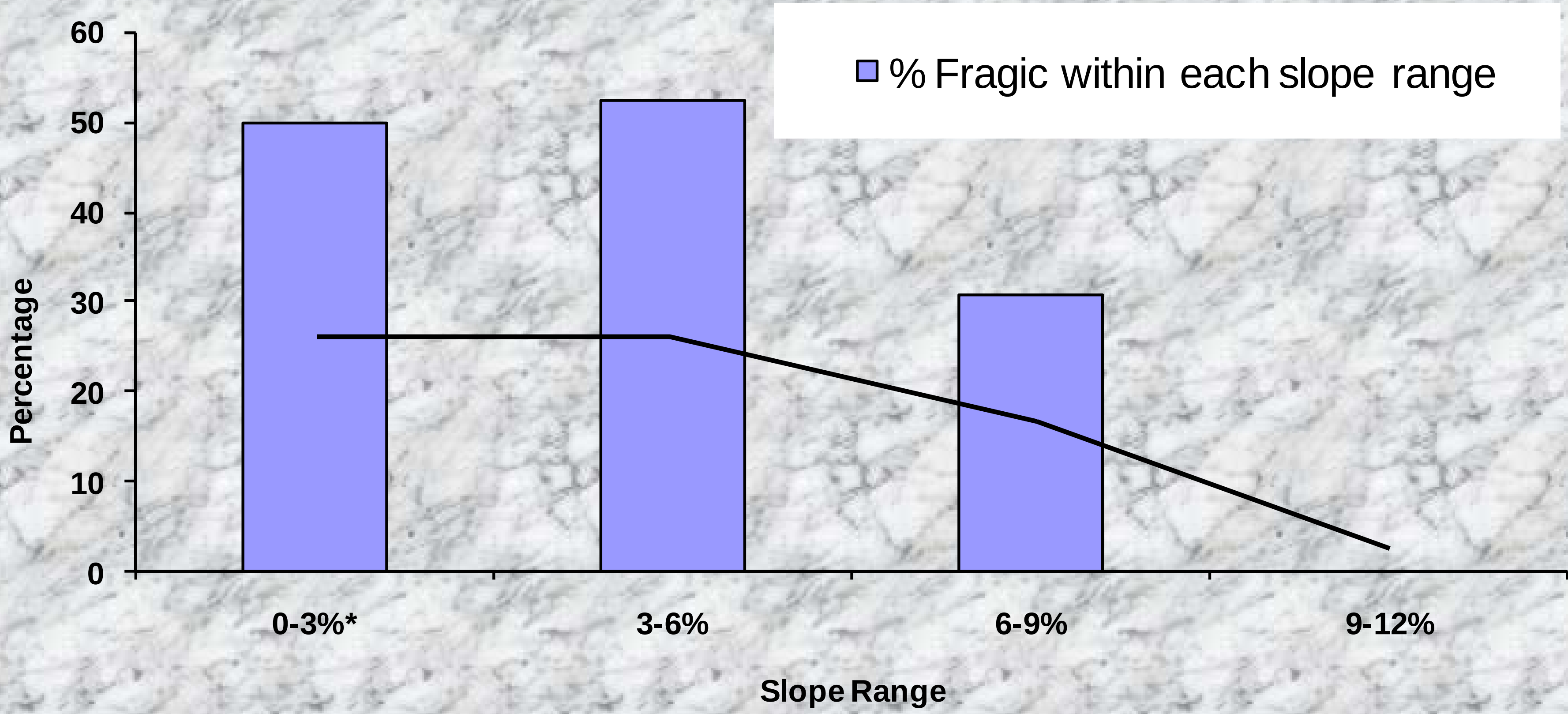
Detailed Soil Survey – Preliminary Results

Loess Thickness



Fragic Properties vs. Terrain Attributes (Slope)



0-3%* - From total of 5 points, 3 fall on the channel, therefore excluded from the calculations

Hydraulic Conductivity at the Pasture Site

Hydraulic Conductivity

- Most of the loess horizons are notably uniform (0.3-0.6 cm/hr);
- With exception of the summit position, most fragipans/fragic horizons had substantially lower Ksat values compared to overlying horizons;
- 5 of the 7 fragic horizons were 1 order of magitude lower (0.02-0.05 cm/hr).

Progress – Water movement monitoring

- Piezometers and Wells:
  - 20 piezometers at two depths and three landscape positions;
  - 6 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
  - 24 sensors at two depths;
  - hourly readings with pressure transducers and dataloggers.
- Rain gauges
  - 2 rain gauges installed at pasture and forested watersheds.
  - Continuous readings.

Summit Piezometers & Wells with rain gauge

Courtesy from: Norm Stephens

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Preliminary Hydrology Results

- Forested site has higher water tables and less runoff when compared to the pasture site;
- Flumes allow us to see runoff vs. lateral discharge into the stream;
- Time lag between peak of water table height vs. peak discharge in flume gives us idea of rates of lateral discharge;
- With instruments, we can do a water balance.

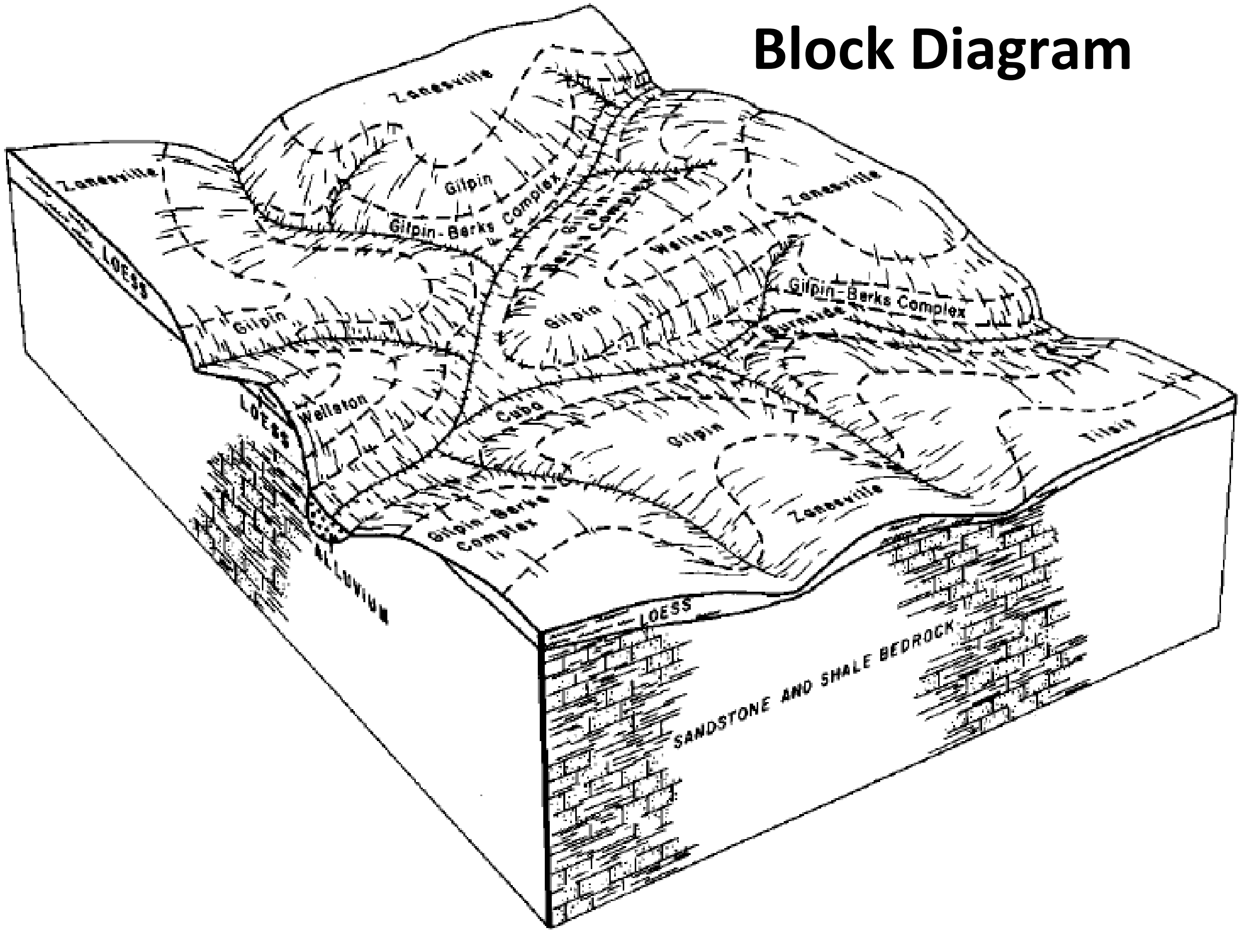
Incorporating information into mapping

S = (p, c, o, r, t, …) (Jenny, 1941)

Soils are determined by the influence of soil-forming factors on parent materials with time.

Parent material
Climate
Organisms
Time
Relief

Block Diagram



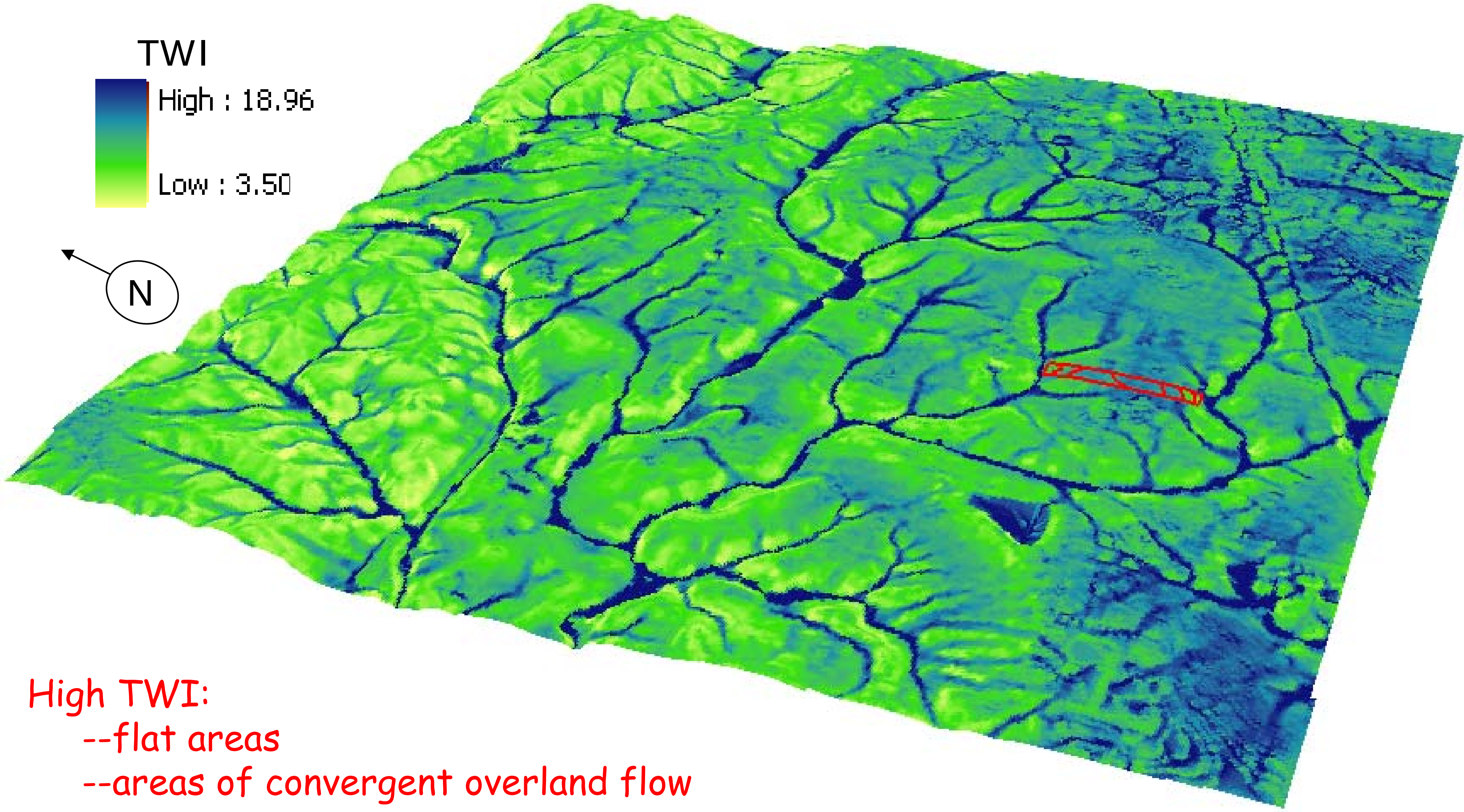
Geostatistical Studies Demonstrated

- Co-kriging with terrain attributes as explanatory variables describes 60-80% of variability (systematic variability);
- High correlation between soil properties and terrain attributes (topography)… no surprise to a pedologist;
- We now have the ability to quantify terrain features (DEM's)
- Conceptual Representations → Quantifiable Predictions.

DEM Derived Terrain Attributes (Topography Descriptors)

- Some of the most commonly used are:
  - Slope;
  - Slope Curvature;
  - Altitude Above Channel Network;
  - Valley Bottom Flatness;
  - Topographic Wetness Index (TWI).

Topographical Wetness Index, TWI

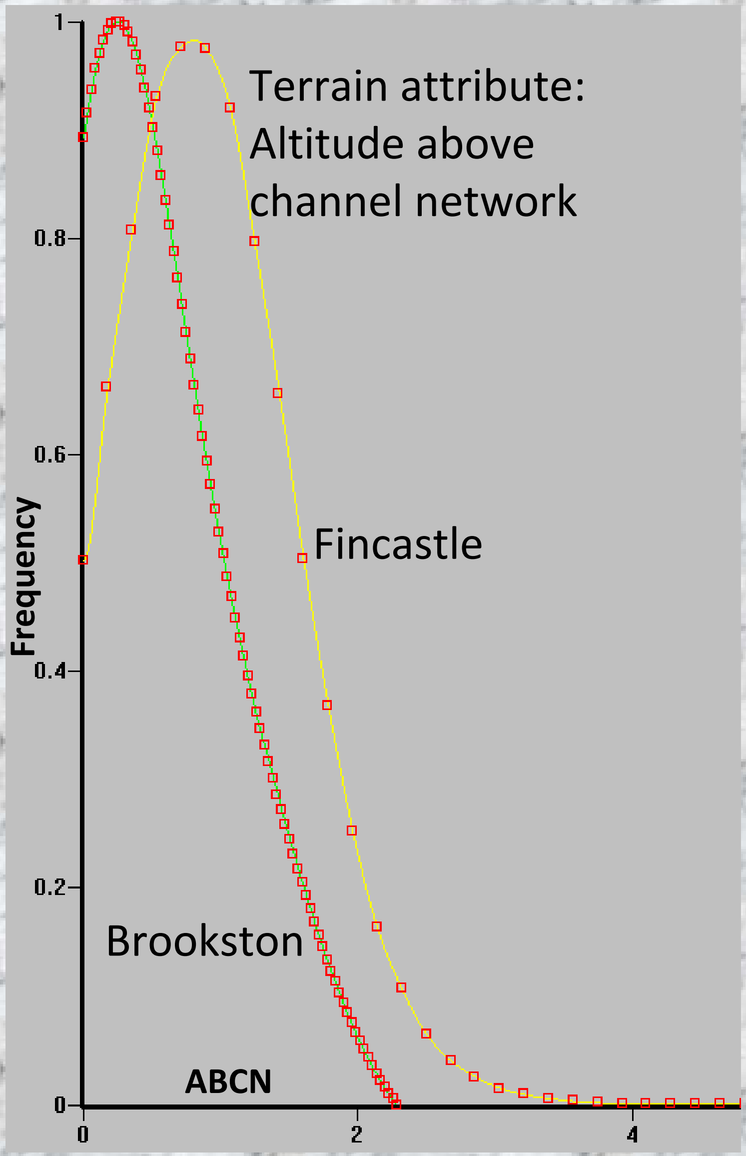


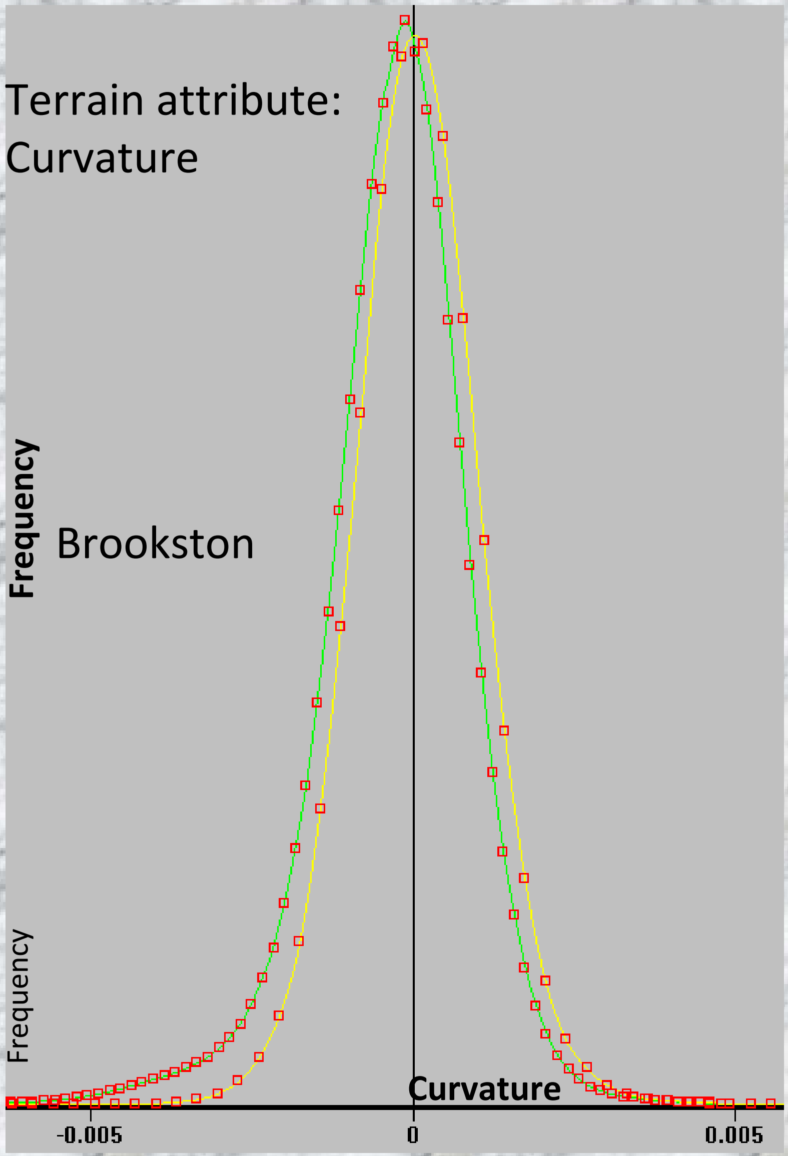
High TWI:

--flat areas

--areas of convergent overland flow

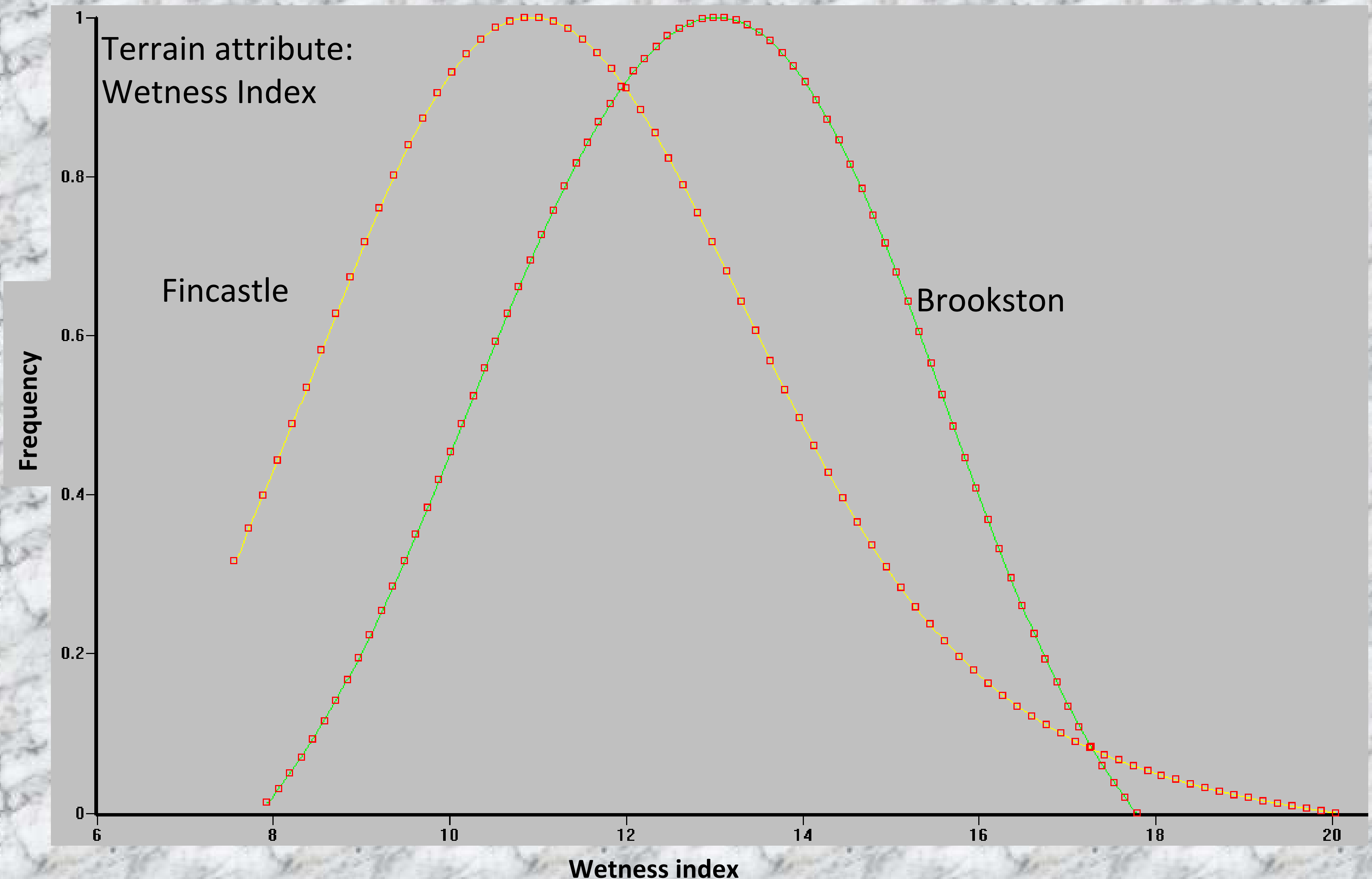
Frequency distributions





*Data extracted with Knowledge Miner Software

Frequency, Wetness Index

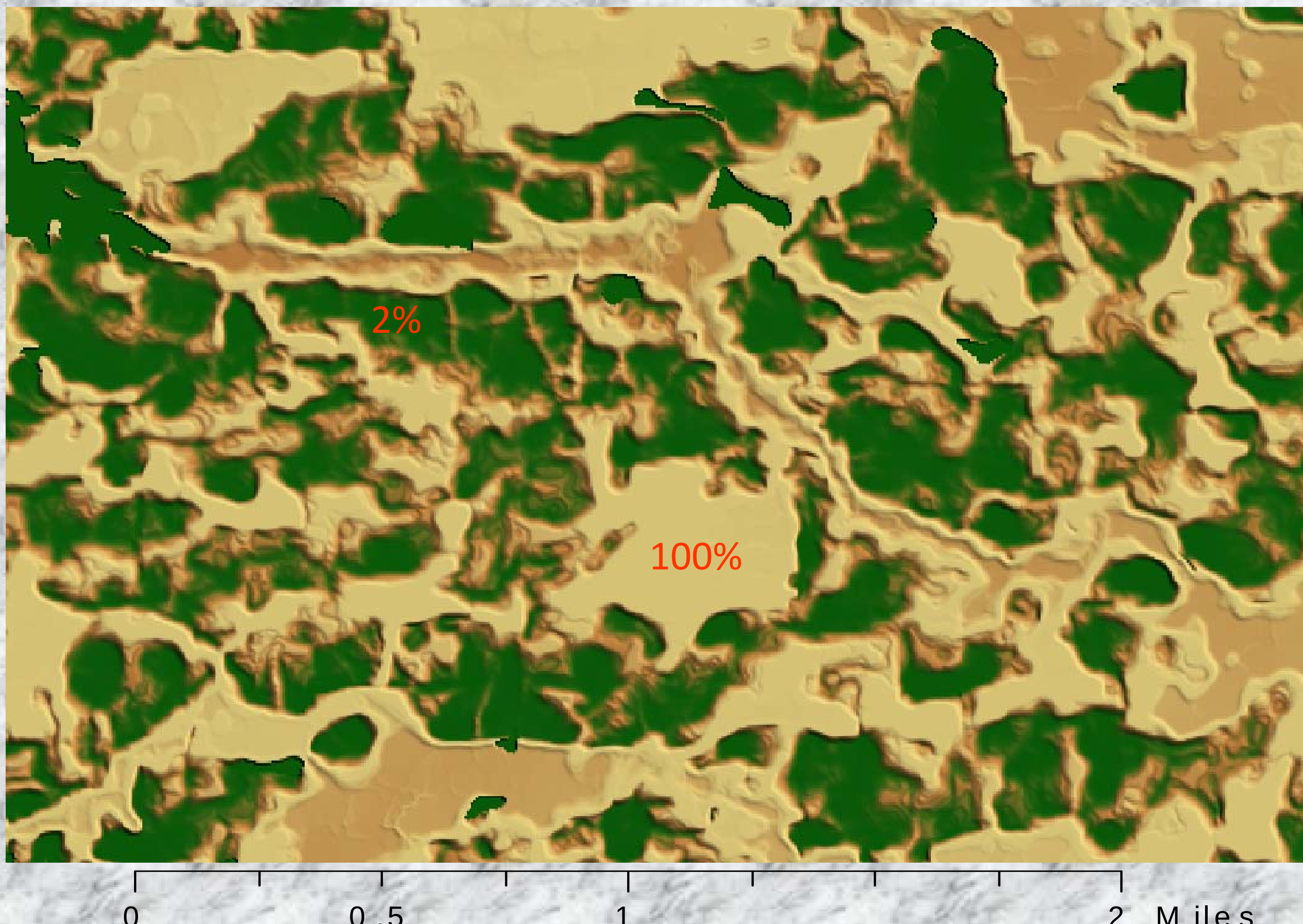


*Data extracted with Knowledge Miner Software

Terrain-Soil Matching for Brookston

*Information derived from Soil landscape Interface Model (SoLIM)

Fuzzy membership values (from 0 to 100%)



Create Property Map with SoLIM

To estimate the soil property SoLIM uses:

$$D_{ij} = \frac{\sum_{k=1}^{n} S^k{}_{ij} * D^k}{\sum_{k=1}^{n} S^k{}_{ij}}$$

D_{ij}: the estimated soil property value at (i, j);
$S^k{}_{ij}$: the fuzzy membership value for kth soil at (i, j);
D^k: the representative property value for kth soil.

In this case, let's assign values to carbonate depth for Fincastle and Brookston in the east section of the county.

Fincastle: 100 cm (low range of OSD)
Brookston: 170 cm (high range of OSD)

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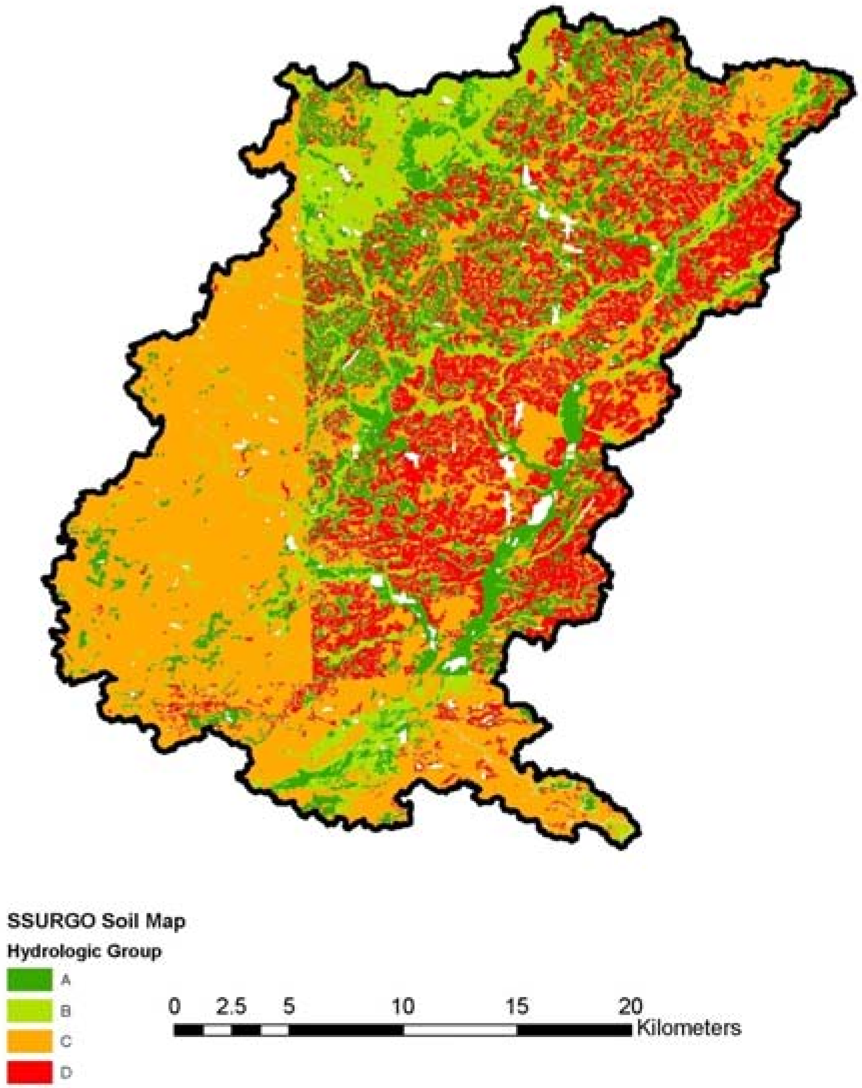
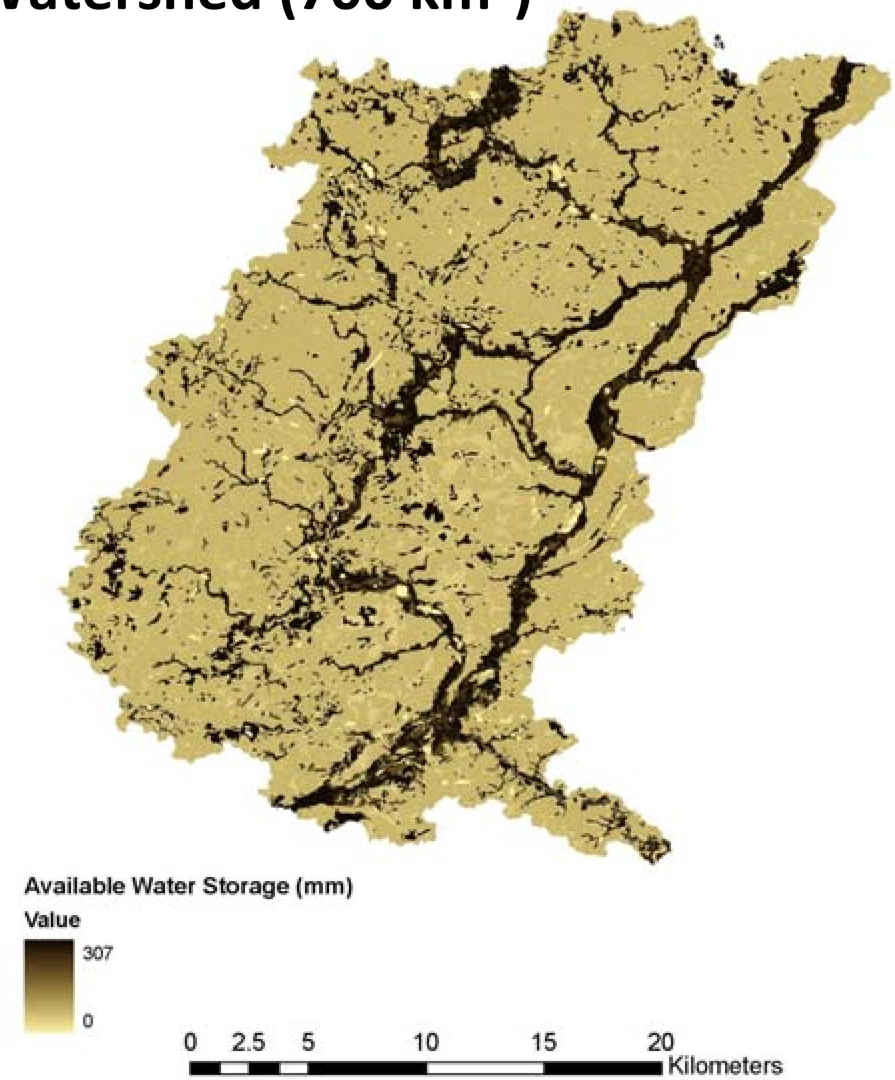
Cedar Creek Watershed (700 km^2)





Conclusions

- Soil Survey for the entire US is scheduled to be completed by 2010. We need to discover ways to best utilize this resource;
- Long-term sites provide the basis for understanding processes and evaluating new techniques to use on entire MLRA;
- Understanding processes related to soil variability provides a means for point data to be extrapolated to broader areas to better describe systems and system function (scaling);
- Strengthens the Soil Survey University Cooperator relationship.