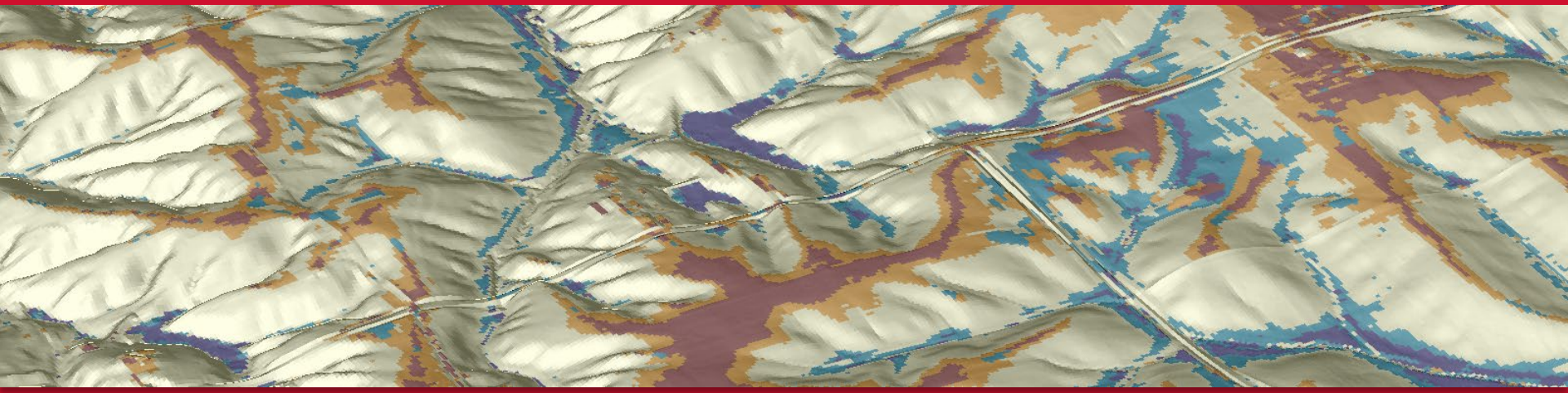


Meyer Bohn – DataFEWSion – Symposium

Jan. 20, 2021

ENHANCING SOIL MAPS FOR PRECISION AGRICULTURE

Geospatial Laboratory for Soil Informatics

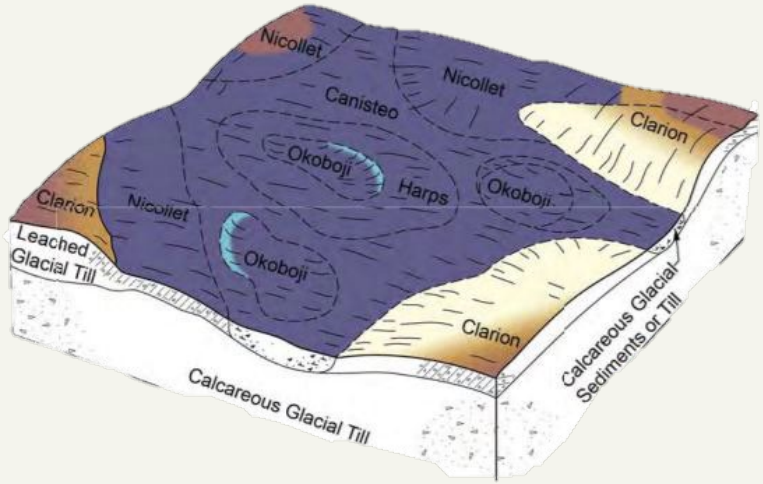
Iowa State University
Department of Agronomy

RECAP

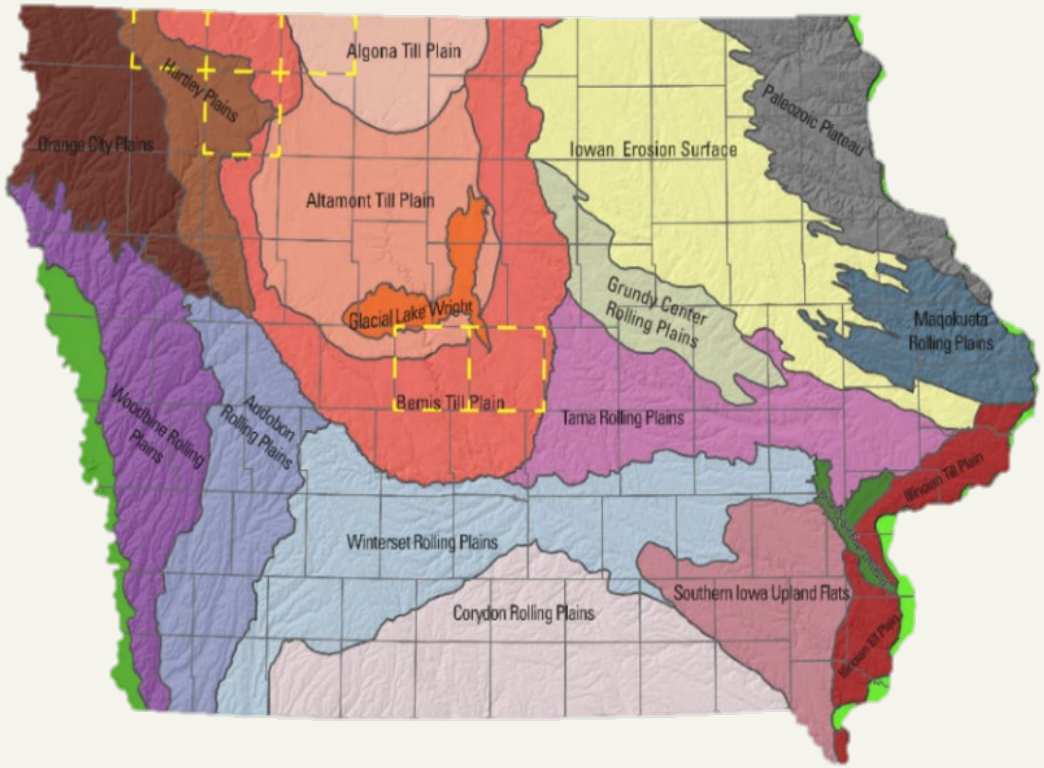
Objective: Map key properties that differentiate soil productivity and function.

1. Topsoil thickness (Depth of Mollic Colors)
2. Soil organic matter (OM)
3. Soil texture (sand, silt, clay, gravel)
4. Depth to Water Table (Reduced Matrix – Gleyic)

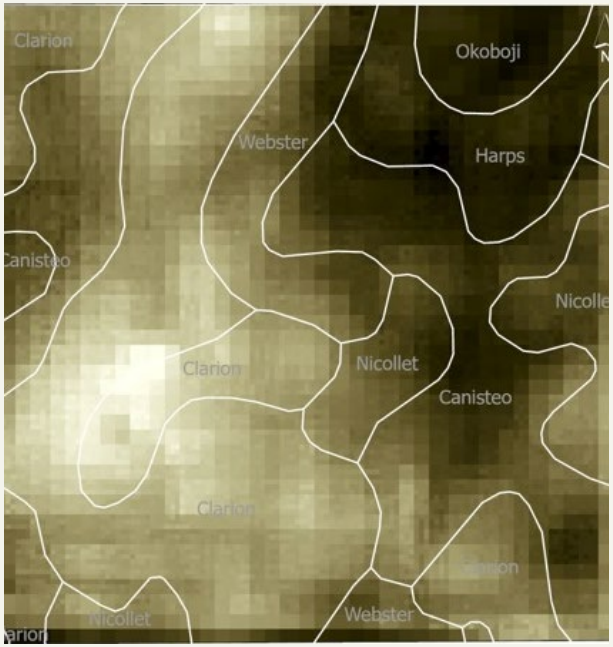
Clarion-Nicollet-Webster (97%)

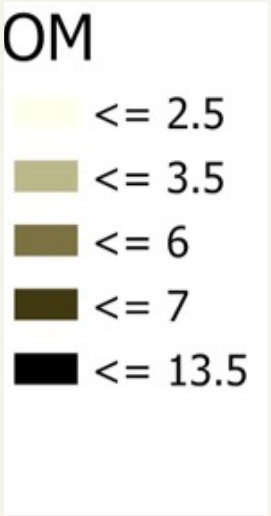


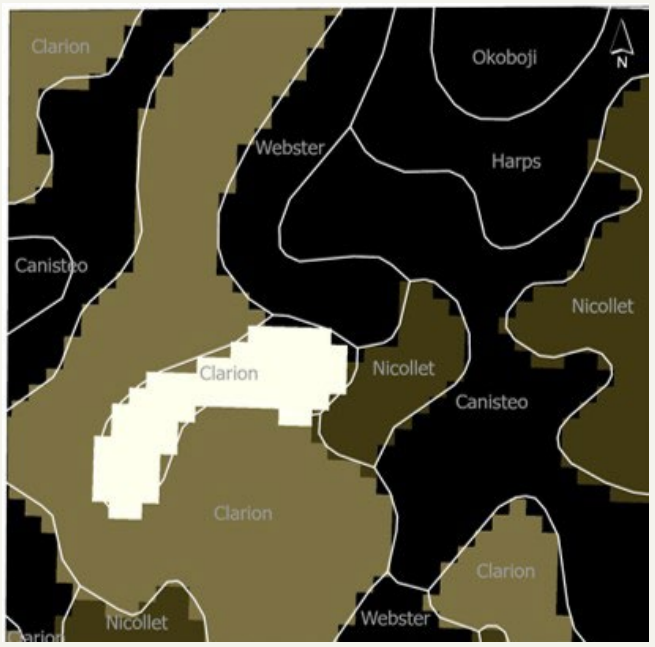
Des Moines Lobe (DML)



HYPOTHESIS







DigitalSoilMapping > **SoilSURveyGeOgraphic**

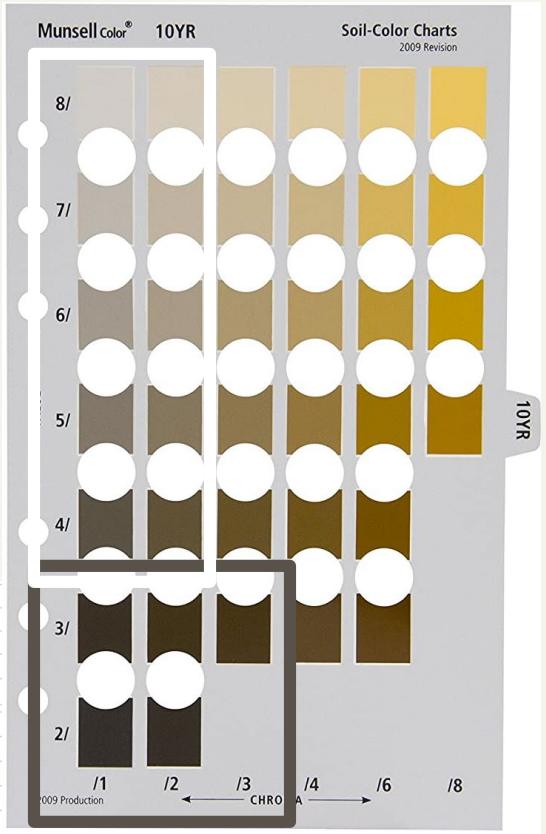
Map Accuracy & Precision

NEED FOR ENHANCED SOIL MAPS

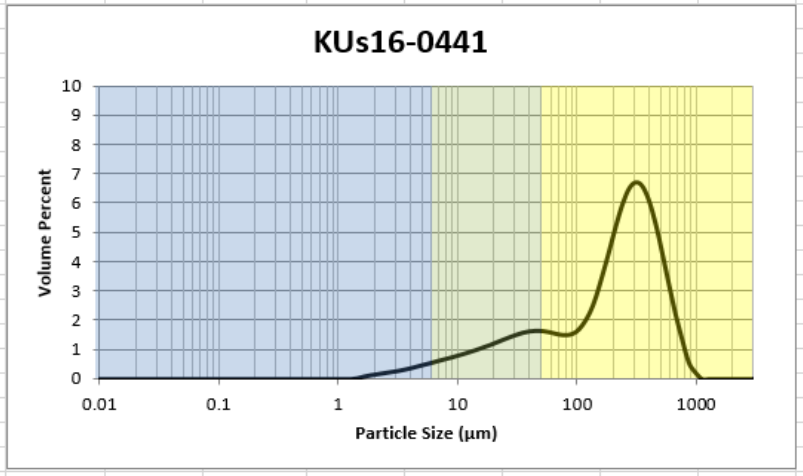
- Soil Maps age > 30 yrs
  - Old data – soil change
  - Made with antiquated technology
- Coarse resolution
  - Average delineation is 10 acres

TARGET PROPERTIES

- Thickness of mollic colors (cm)
  - Value and Chroma <= 3
  - “Topsoil thickness”
- Depth to gleyic horizon (cm)
  - >50% Chroma <=2 & Value >= 4
  - Long term saturation – “Water table depth”
- Texture (%) – sand, silt, clay
  - Laser diffraction
- Organic Matter (%)
  - Loss on Ignition



Sample ID: KUs16-0441							
Clay	*Silt*	*Sand*	*vfs*	*fs*	*ms*	*cs*	*vcs*
5.4	15.7	78.9	11.5	20.4	33.9	13.0	0.2
Soil Texture Class:		**loamy sand**		Primary mode:		49.4 µm	
First mode:		49.4 µm		Second mode:		335.0 µm	



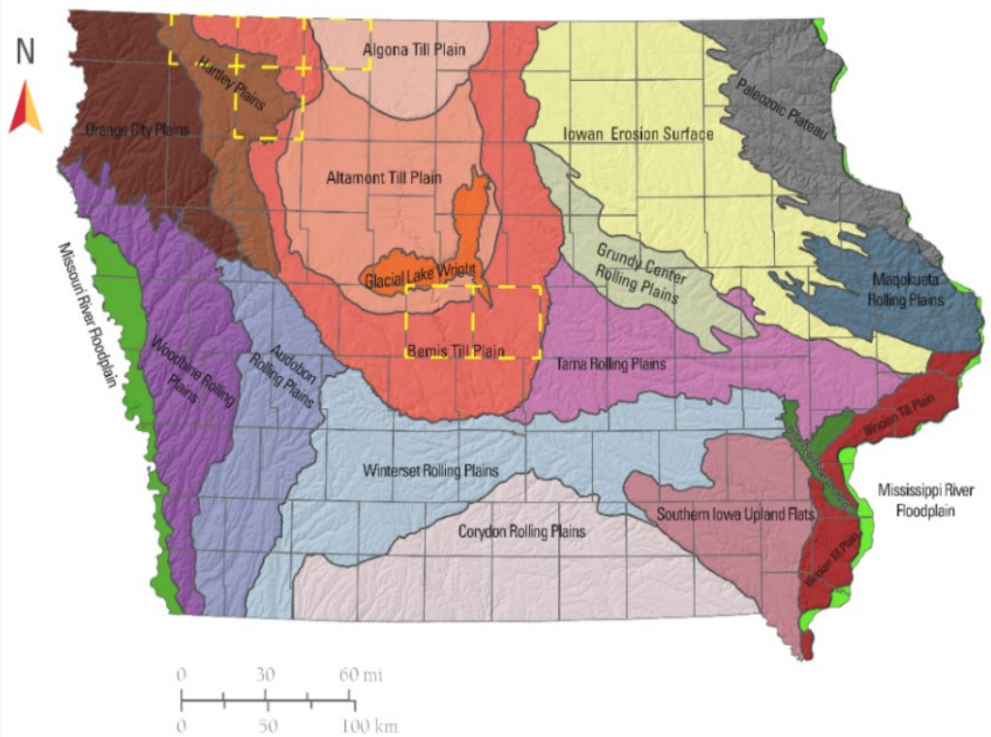
OBJECTIVES - DETAILS

Comparative Performance w SSURGO

- Map key properties
  - Continuous
    - Sand, silt, clay, organic matter at 7 depths
    - 0-5, 5-15, 15-30, 30-60, 60-100, 100-200 cm
    - Topsoil thickness, Depth to water table
  - Classified
    - Gleyic = Binary – presence/absence
- Compare performance with soil survey (SSURGO)
- 10% random independent validation
  - Continuous = Root mean squared error (RMSE)
  - Classified = Percent Accuracy

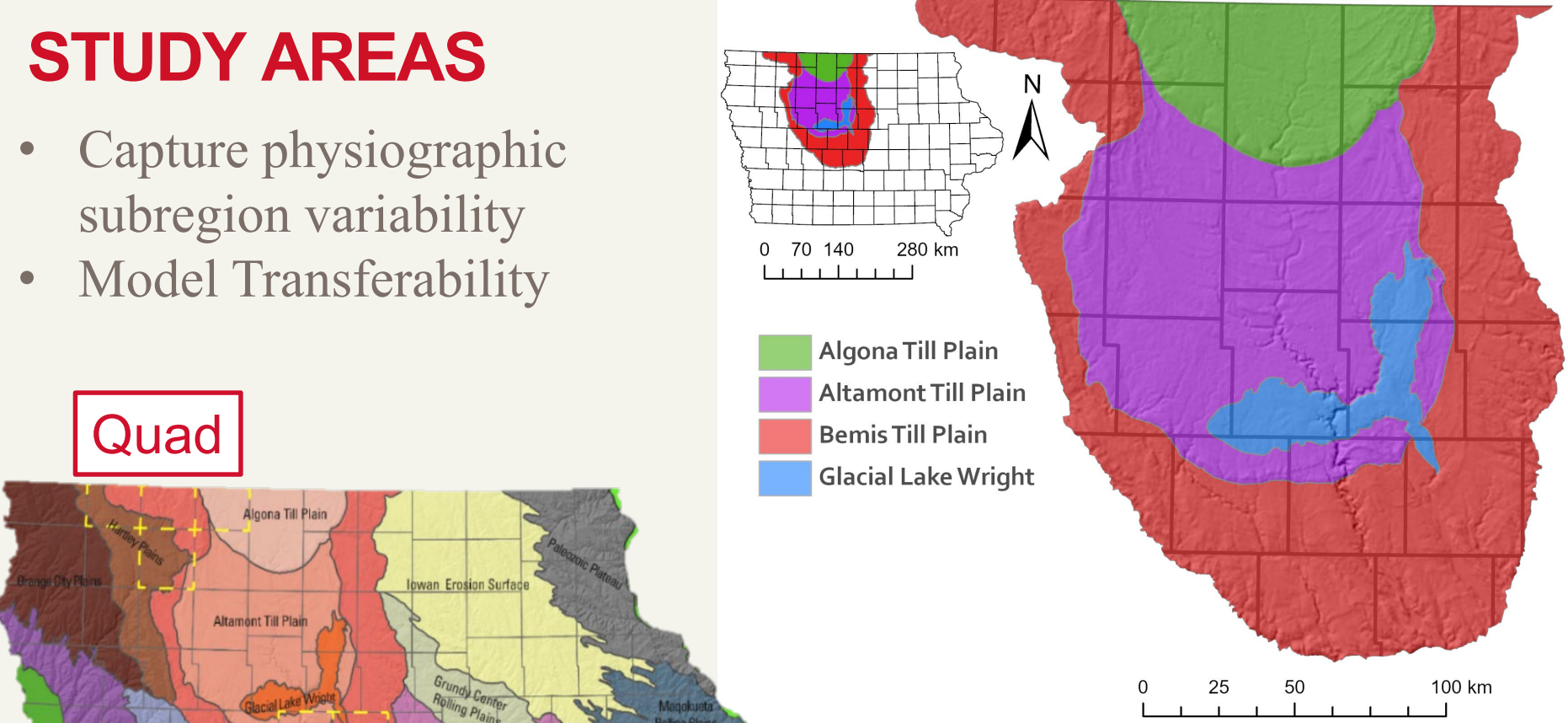
Model Transferability within DML

- Two study areas – Quad & Story-Boone
  - Test independent study area models on each other

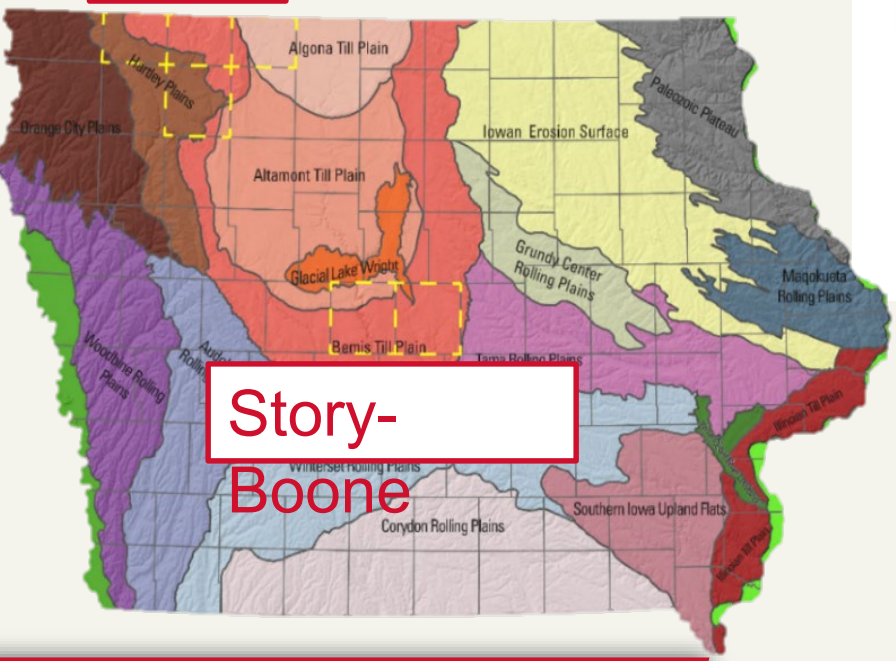


STUDY AREAS

- Capture physiographic subregion variability
- Model Transferability



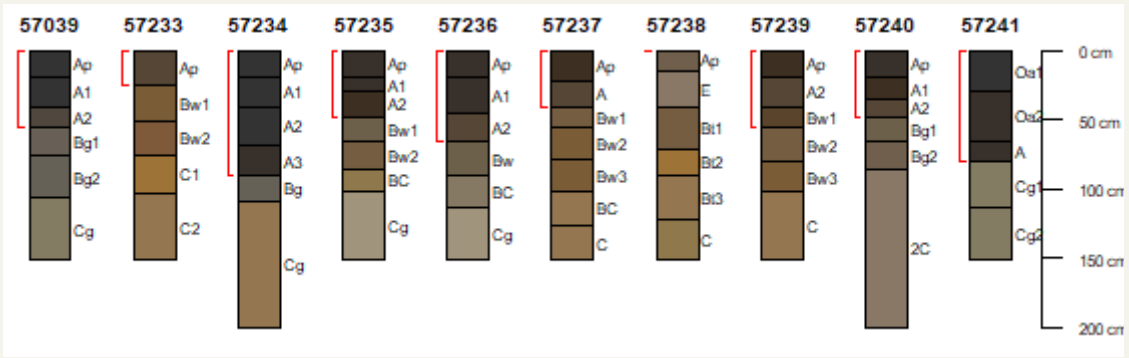
Quad



Story-Boone

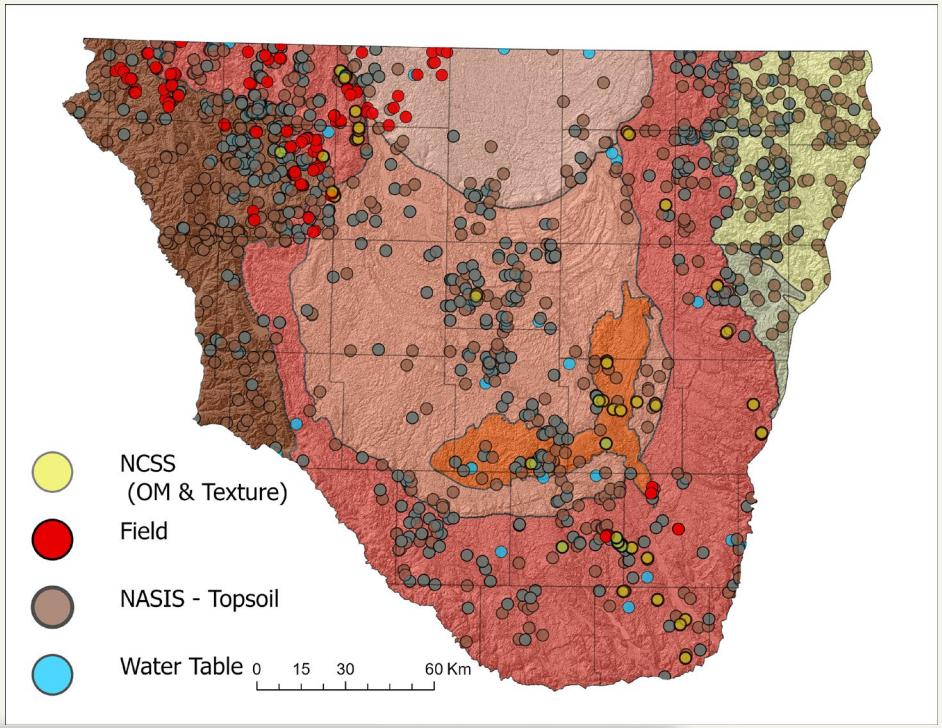
Algona – young, knob and kettle topo
Altamont – washboard moraines, end moraines, weak drainage
Bemis – oldest, most integrated drainage
GLW – glaciolacustrine, level topo, fine sediments

DATA COLLECTION – FIELD – 200 SAMPLES



DATA COLLECTION - DATABASES

- National Soil Information System (NASIS)
- National Cooperative Soil Survey (NCSS) Characterization Database



Depth (cm)	
	n
mollic	1140
gleyic	415

Presence/Absence	n	present	absent
gleyic	940	415	525

PSD (%)	n	SOC (%)	n
clay			
0-5	112		
5-15	112	0-5	65
15-30	111		
silt		5-15	65
0-5	112		
5-15	112		
15-30	110	15-30	65

LAND SURFACE DERIVATIVES (SOIL-FORMING PREDICTORS)

Digital Terrain Analysis

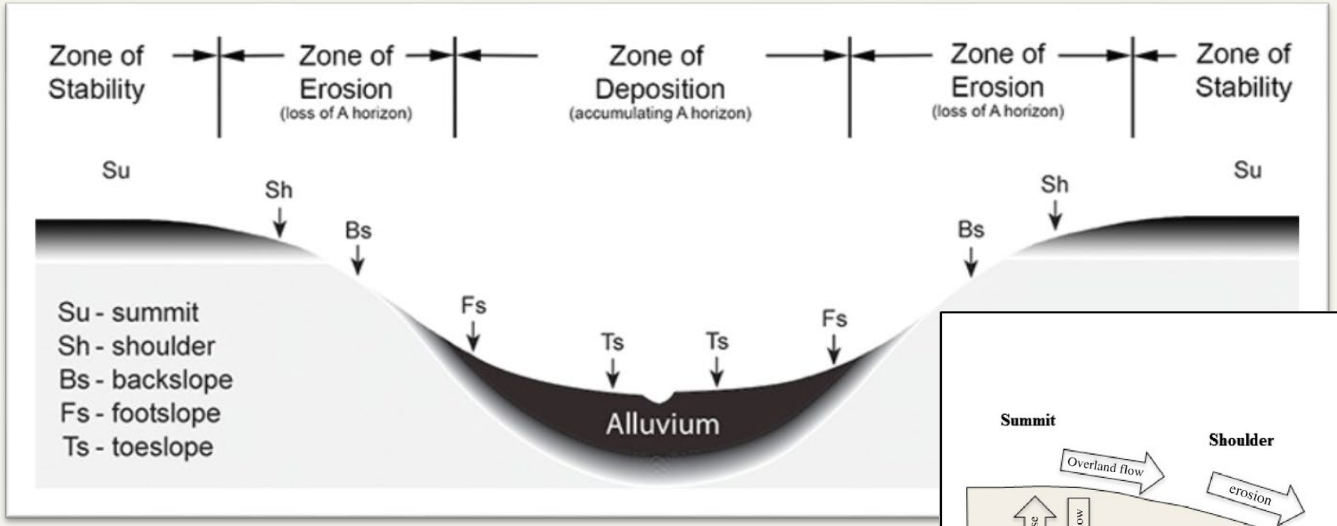
- Slope, profile, plan, cross-sectional curvatures, aspect
  - Analysis Scales – 9m to 5070m
- Topographic position index, relative elevation
- Saga Wetness and Topographic Wetness Index

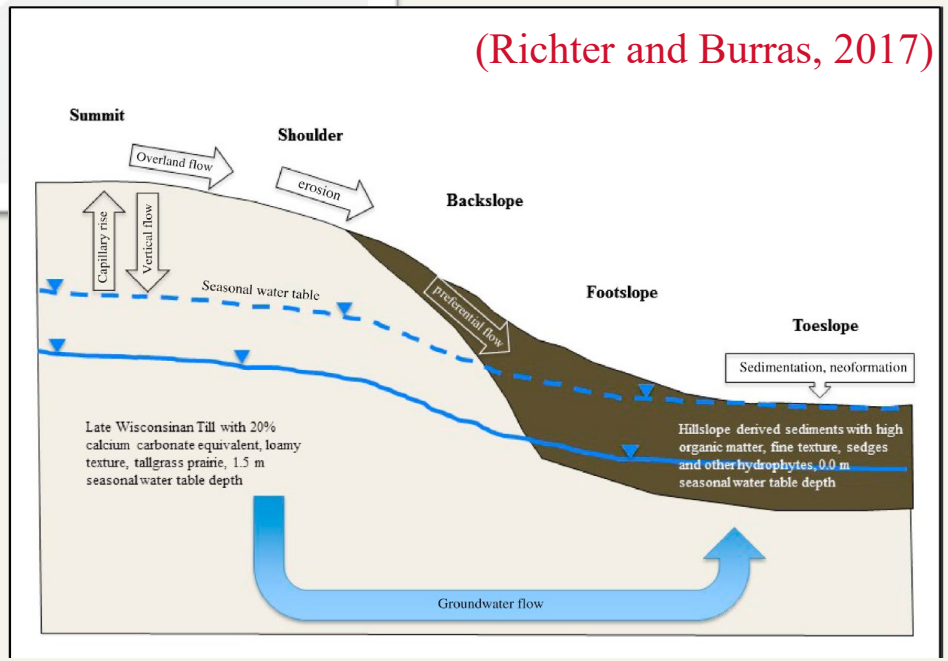
Remote Sensing

- Landsat imagery
- Landcover Classification
- National Ag Imagery Program (NAIP)

SOIL GEOMORPHOLOGY

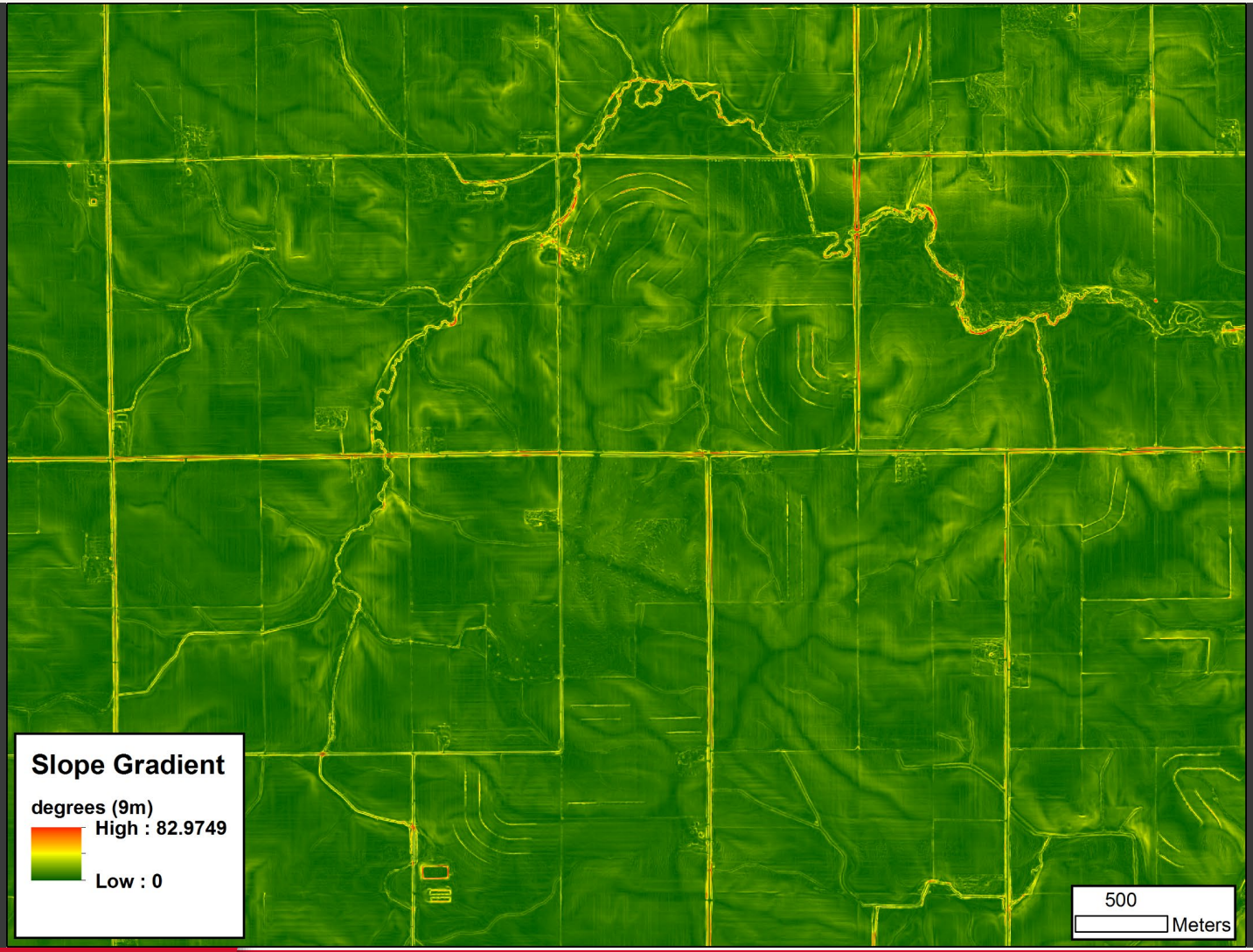
- Strong relationship with topography



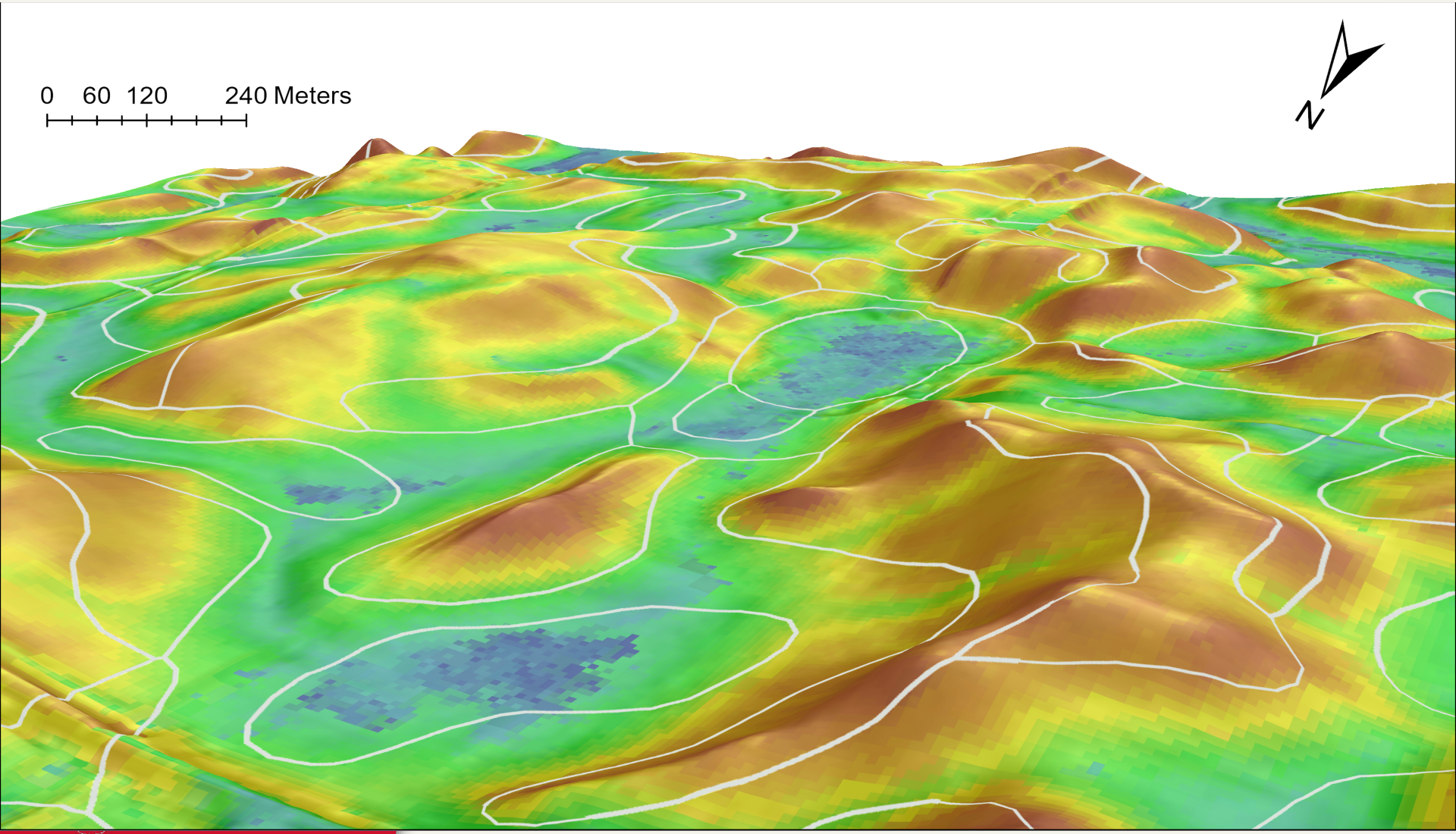


- Upland Soils - ↓ OM, clay, topsoil thickness, deep water table
- Lowland soils - ↑ OM, clay, topsoil thickness, shallow water table

Analysis Scale

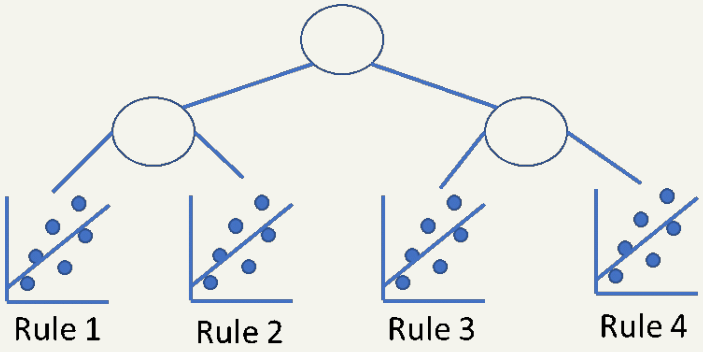


SAGA WETNESS INDEX

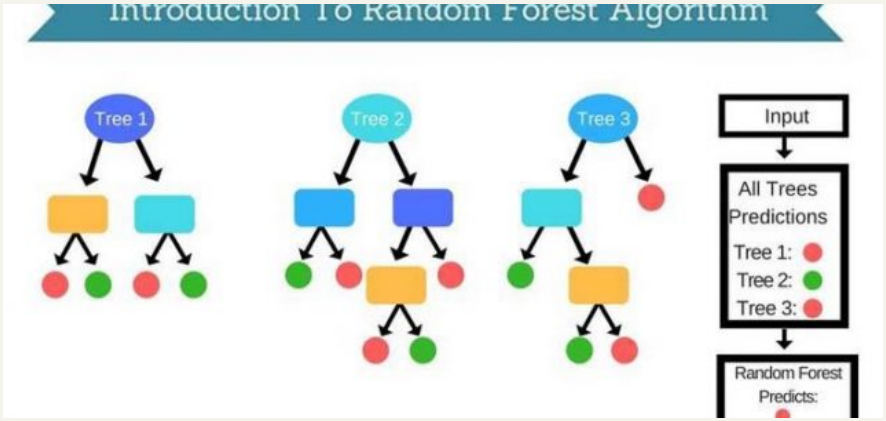


MACHINE-LEARNING

- Continuous Prediction
  - OM, Texture, topsoil thickness, depth to water table (cm)
- Cubist – Rule-based Regression tree



- Classification Prediction
  - Presence/Absence gleyic horizon (water table)
- Random Forests – bagged decision tree



PRELIMINARY RESULTS – CROSS VALIDATION

cm	n	Avg.	SD	cor	avg. error	R2	RMSE	MAE
mollic	1140	44.1	29.3	0.74	13	0.40	23.0	14.6
gleyic	484	66.0	39.0	0.6	19.2	0.12	35.5	21.4

Presence/Absence	n	present	absent	Accuracy	Kappa (κ)
gleyic	940	415	525	0.832	0.658

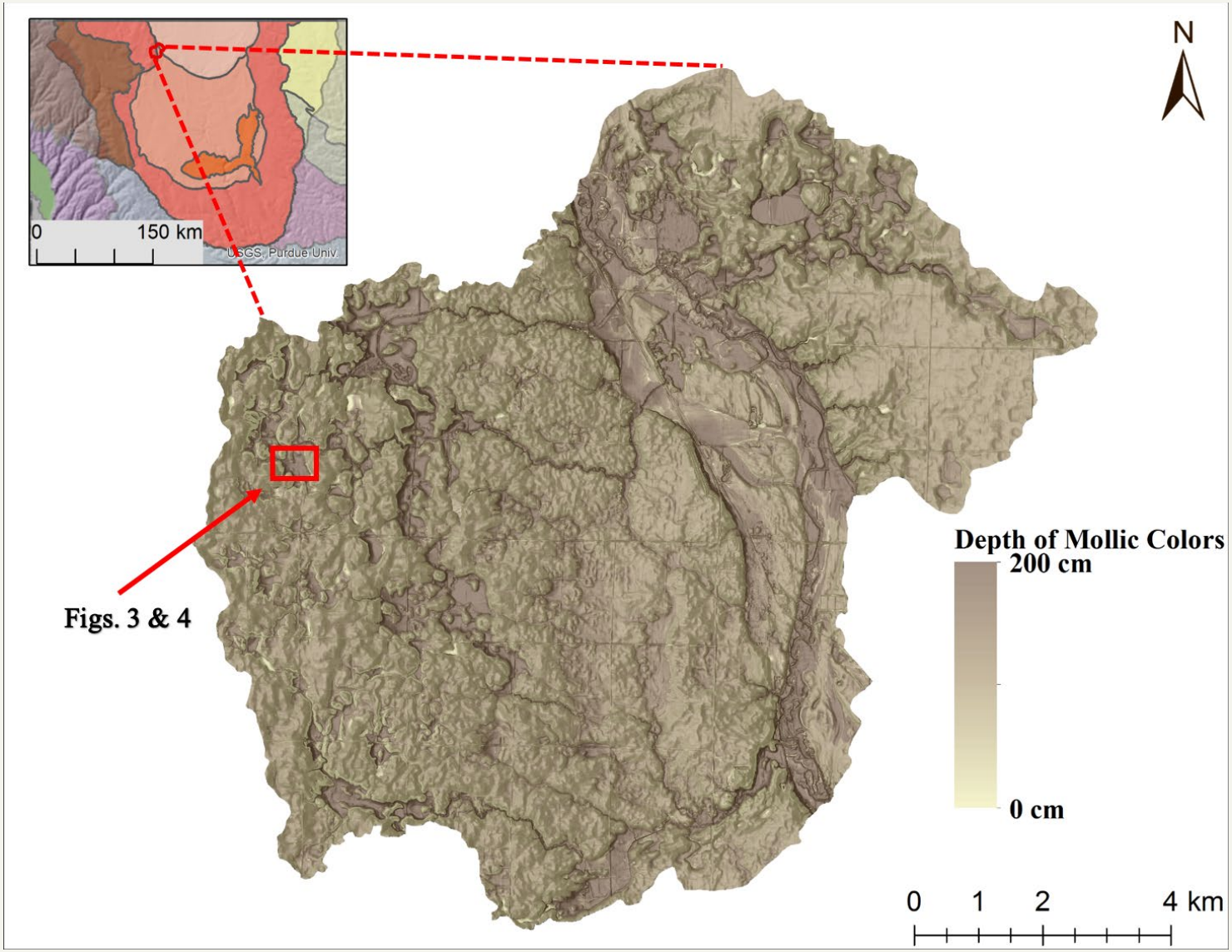
CROSS-VALIDATION

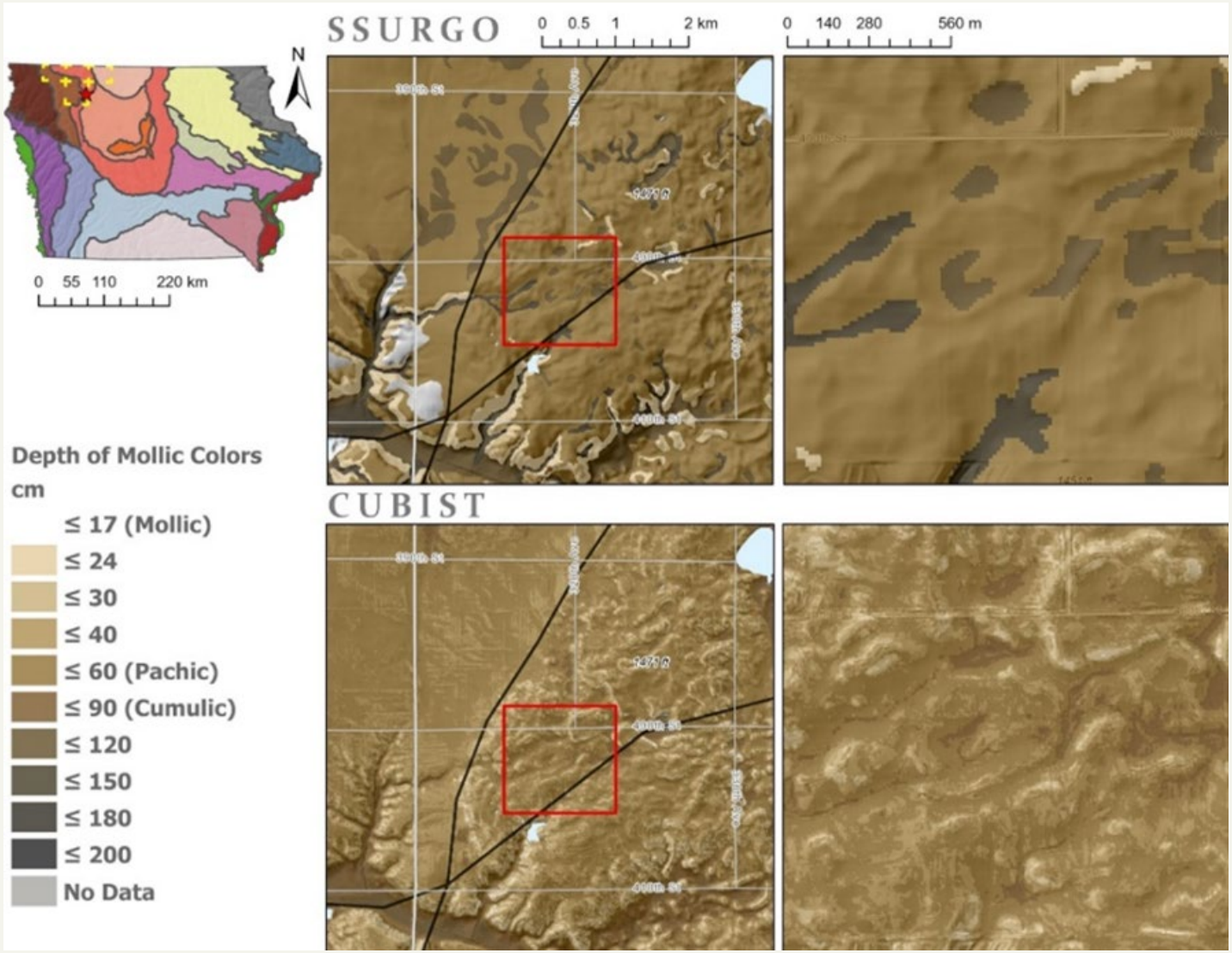
SOC (%)	n	Avg.	SD	cor	avg. error	R^2	RMSE	MAE
0-5	65	1.72	1.02	0.77	0.48	0.34	0.91	0.67
5-15	65	1.66	1.05	0.72	0.58	0.47	0.93	0.64
15-30	65	1.22	1.00	0.79	0.47	0.47	0.83	0.61

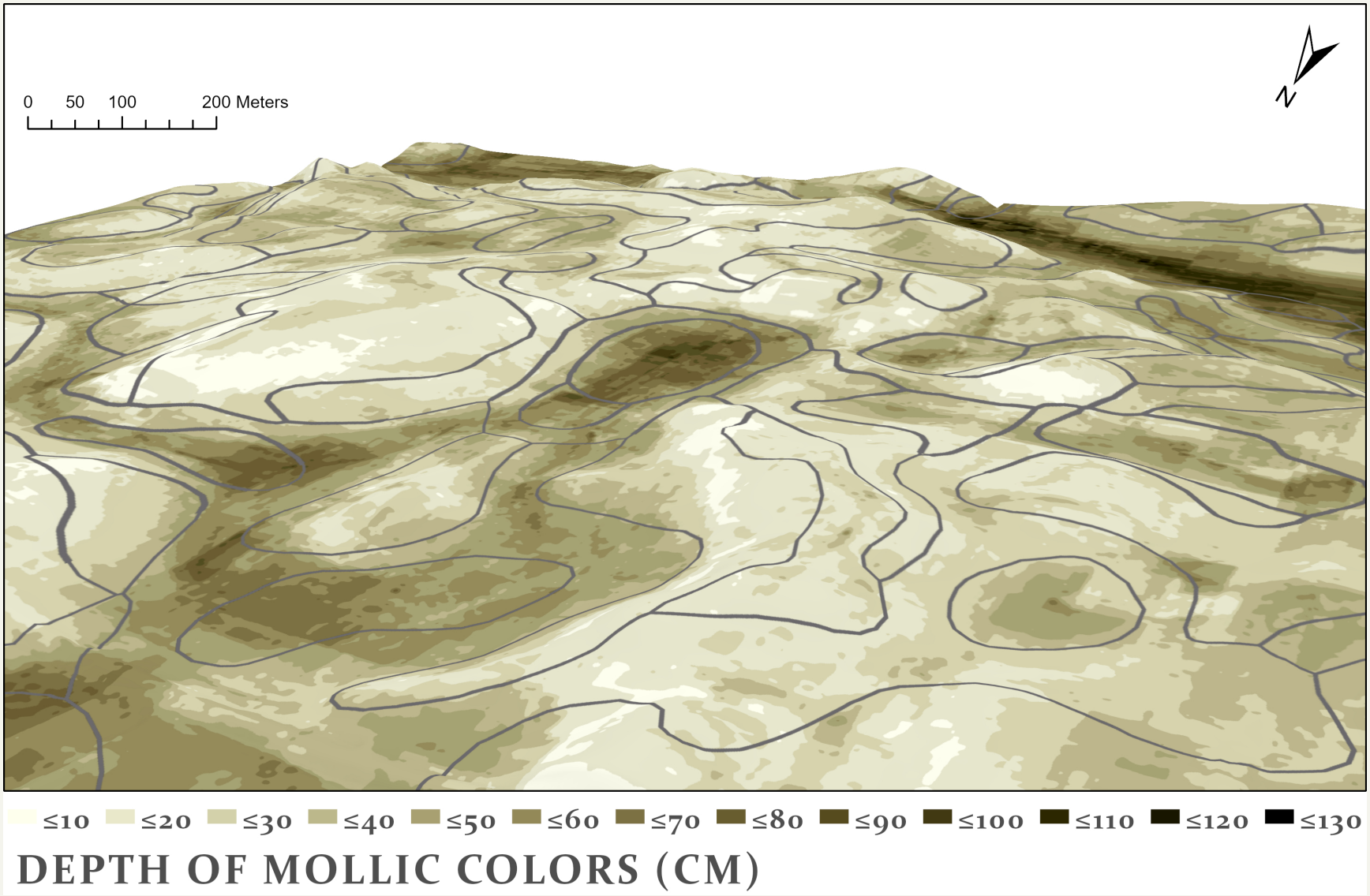
PSD (%)	n	Avg.	SD	cor	avg. error	R2	RMSE	MAE
clay								
0-5	112	22.4	5.6	0.55	3.6	0.19	5.5	4.0
5-15	112	22.5	5.6	0.54	3.6	0.22	5.7	4.2
15-30	111	23.6	6.0	0.67	3.7	0.06	6.4	4.8
silt								
0-5	112	33.4	7.0	0.43	5.8	0.24	7.0	5.5
5-15	112	33.6	7.1	0.65	4.5	0.24	6.5	5.2
15-30	110	34.1	7.6	0.62	5.1	0.19	7.0	5.5

INDEPENDENT MAP VALIDATION

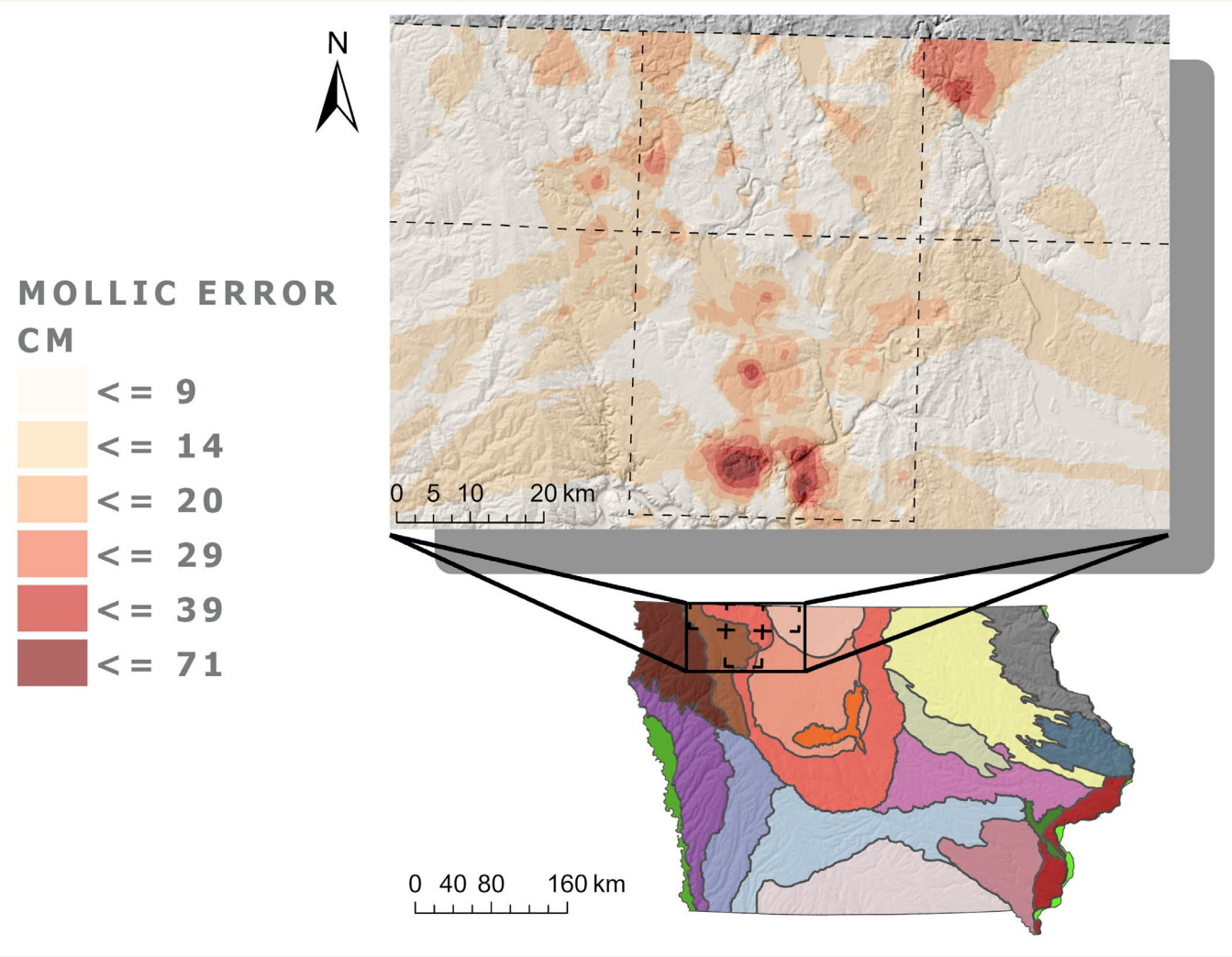
Model		Target		Map-validation	
SSURGO				**RMSE**	**R^2**
Quad		Topsoil thickness (cm)		25.7	0.30
Quad		Depth to water table (cm)		30.3	0.03
State		Sand (%)		12.3	0.21
State		Silt (%)		9.5	0.36
DSM					
Quad		Topsoil thickness (cm)		13.7	0.80
Quad		Depth to water table (cm)		17.7	0.67
State		Sand (%)		7.8	0.68
State		Silt (%)		7.1	0.64


N
0
150 km
USGS, Purdue Univ.
Figs. 3 & 4
Depth of Mollic Colors
200 cm
0 cm
0
1
2
4 km

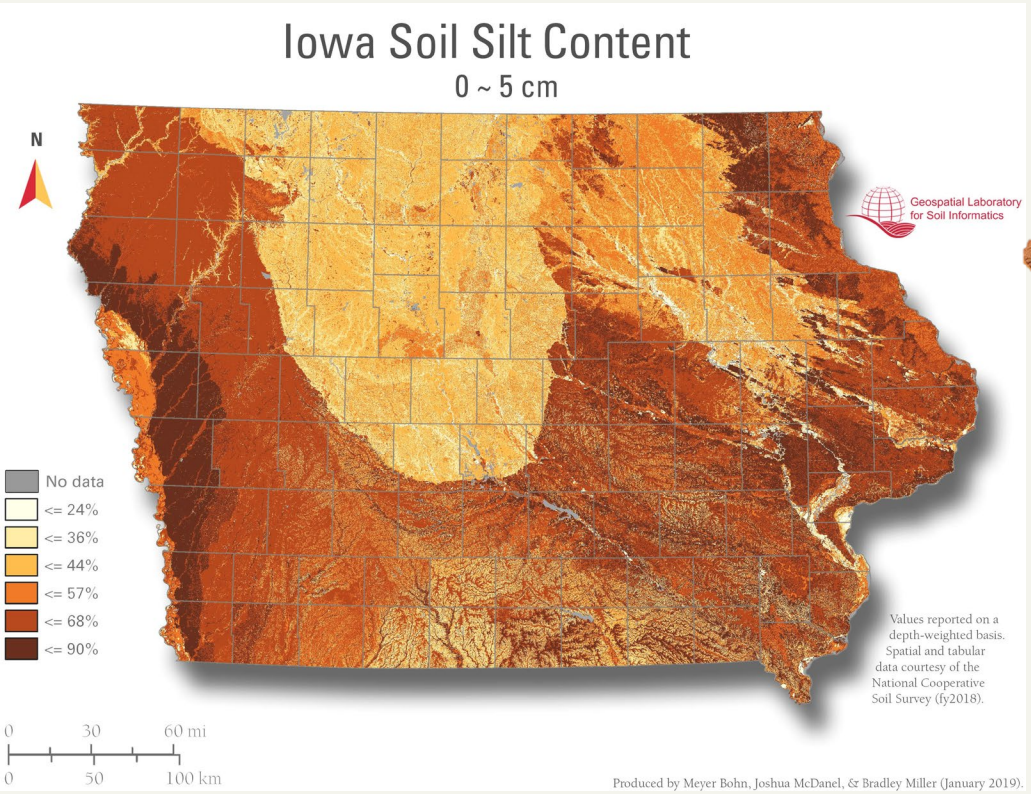

SSURGO
0 0.5 1 2 km
0 140 280 560 m
N
0 55 110 220 km
CUBIST
Depth of Mollic Colors
cm
≤ 17 (Mollic)
≤ 24
≤ 30
≤ 40
≤ 60 (Pachic)
≤ 90 (Cumulic)
≤ 120
≤ 150
≤ 180
≤ 200
No Data


0 50 100 200 Meters
N
≤10 ≤20 ≤30 ≤40 ≤50 ≤60 ≤70 ≤80 ≤90 ≤100 ≤110 ≤120 ≤130
DEPTH OF MOLLIC COLORS (CM)

RESIDUAL ERROR MAP



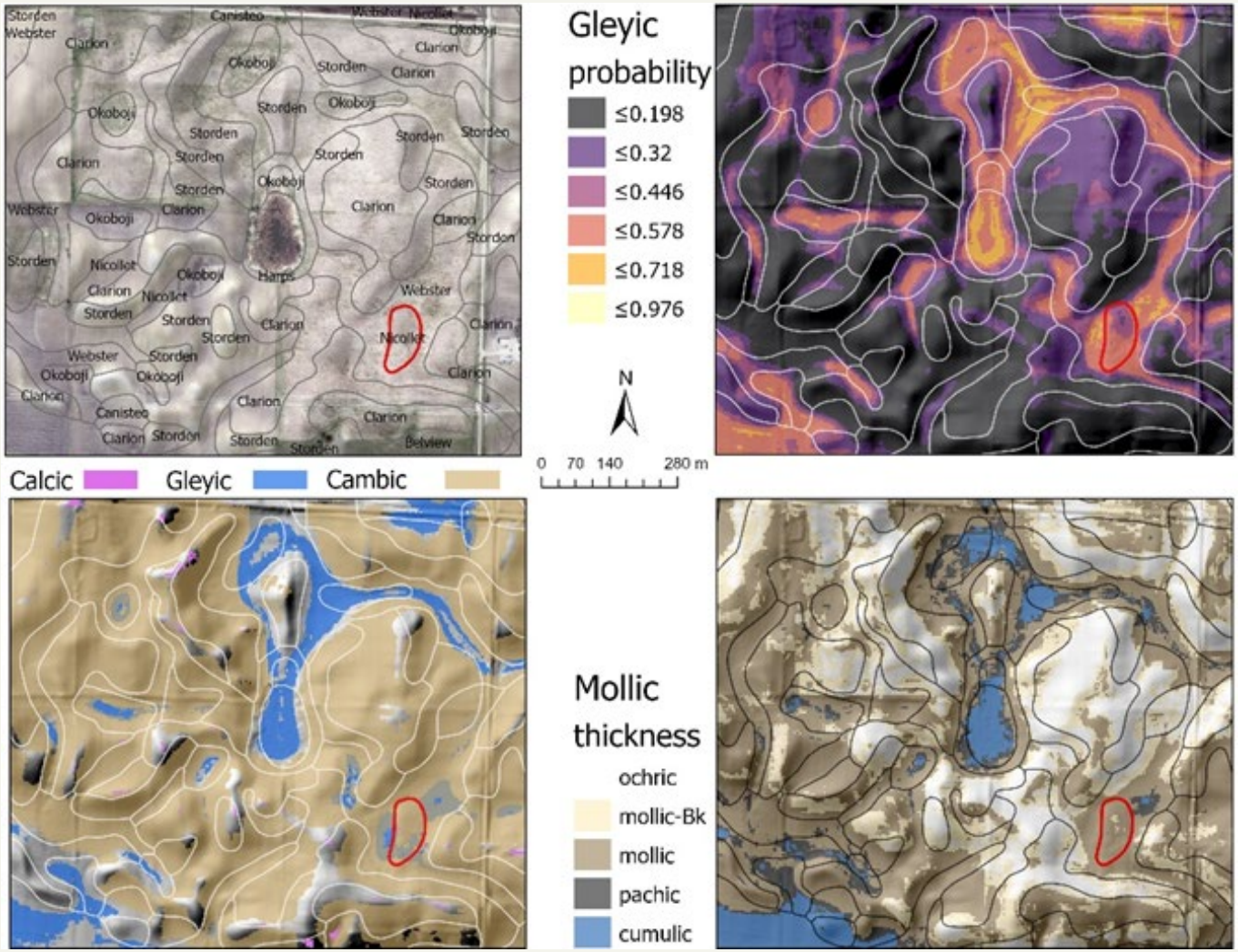
SSURGO VS DSM SILT CONTENT



SSURGO

DSM

OTHER PRELIMINARY RESULTS



CONCLUDING REMARKS

- Slated for completion 12/2021
- Future - Sensitivity analysis of DSM maps vs. SSURGO in soils input data for corn yield predictions with APSIM model
- Thanks to Iowa Water Center for funding and many more
  - Major advisor – Bradley Miller
  - Lab members – Joshua McDaniel, Caner Ferhatoglu, Luis Bentancor, Dustin Ehret, Emma Malburg
  - Field and laboratory assistants – Jacob Schultz, Hunter Bloom, Will Montgomery, Aaryn Graeve, Elizabeth Foster, Robyn Byl
  - Iowa Farmers and Schultz Family!